ONTARIO

DEPARTMENT OF MINES

OPERATION KAPUSKASING

By

G. BENNETT, D. D. BROWN, R. T. GEORGE AND E. J. LEAHY

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MAPS

P. 420 Aeromagnetic - geologic compilation map of the Operation Kapuskasing area (in press)

P. 370-373, 375, 376, 395-398 available from Publications Office, Ontario Department of Mines, Parliament Buildings, Toronto 2. Price, 50 cents each (Ontario orders please add 5 percent sales tax).

ABSTRACT

The oldest rocks in the area are metavolcanic and metasedimentary rocks, and related gneisses, that have been folded and intruded by Archean mafic to felsic rocks. High grade, granulite facies metamorphic rocks, uncommon in the Superior Province, underlie a wedge-shaped zone in the north-central part of the area that correlates closely with the prominant regional aeromagnetic feature, the Fraserdale - Moosonee anomaly. These rocks are probably of Archean origin but were faulted into place during Proterozoic time. A regional gravity anomaly parallel to and west of the aeromagnetic anomaly indicates a major zone of upwarp and thinning in the earth's crust.

Associated with the zone of uplift and northeast striking faults are carbonatite intrusions of Proterozoic age and lamprophyric to kimberlitic intrusions of post middle Devonian age. The carbonatites contain columbium, copper, and iron mineralization, and the kimberlite could be a source of diamonds.

The northern portion of the area is underlain by generally flat-lying Paleozoic and Mesozoic sedimentary rocks. The whole area is blanketed with Pleistocene and Recent sediments.

Occurrences of base metal and related sulphides, nickel, gold, iron, lithium, molybdenum, columbium, uranium, and thorium are reported in the area.

OPERATION KAPUSKASING

By

G. Bennett, D.D. Brown, P.T. George, and E.J. Leahy[1]

INTRODUCTION

LOCATION AND ACCESS

The Operation Kapuskasing area lies mainly within the District of Cochrane with the southwest corner in the District of Algoma; has an areal extent of 28,000 square miles, and comprises the territory bounded on the east by the Ontario-Quebec interprovincial boundary, on the west by longitude 84°00'W, on the south by latitude 49°00'N, and on the north by latitude 51°00'N (Figure 1).

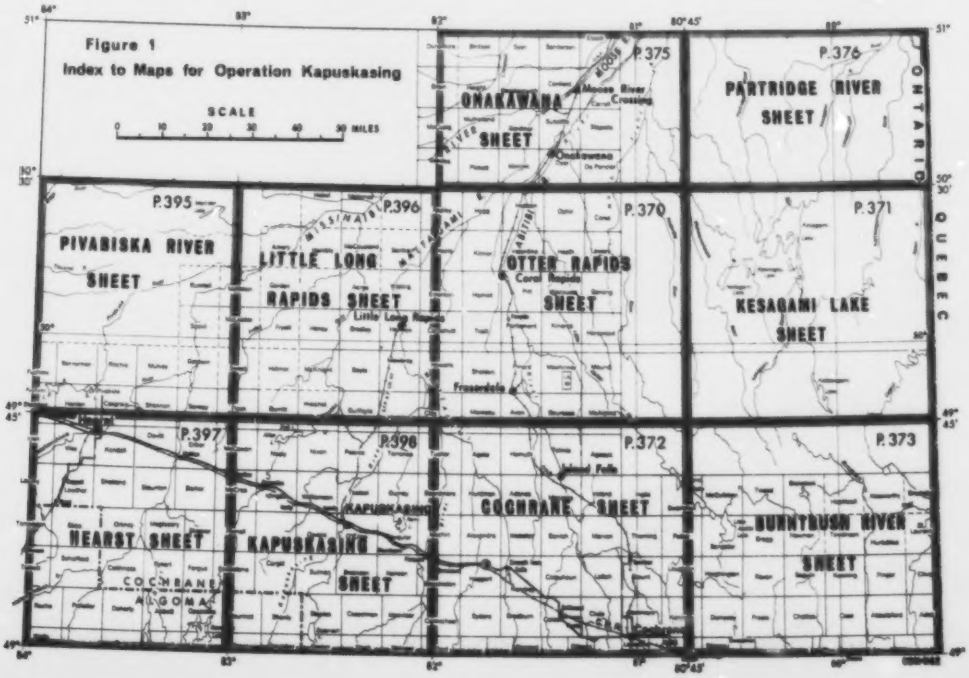

Figure 1
Index to Maps for Operation Kapuskasing

SCALE
0 10 20 30 40 50 MILES
P.375
ONAKAWANA SHEET
P.376
PARTRIDGE RIVER SHEET
ONTARIO
QUEBEC
P.395
PIVABISKA RIVER SHEET
P.396
LITTLE LONG RAPIDS SHEET
P.370
OTTER RAPIDS SHEET
P.371
KESAGAMI LAKE SHEET
P.397
HEARST SHEET
P.398
KAPUSKASING SHEET
P.372
COCHRANE SHEET
P.373
BURNTBUSH RIVER SHEET
COCHRANE
ALGOMA
KAPUSKASING
51°
50° 30'
49° 45'
49°
84°
83°
82°
81°
80°45'
80°

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[1] Geologists, Ontario Department of Mines.

Manuscript received by The Director, Geological Branch, 2 May, 1967.

Accessibility varies throughout the area. Highway 11 from Cochrane to Hearst divides the area and along with secondary roads provides good access an average of five to ten miles north and south of the highway. Highway 807, north from Smooth Rock Falls serves the Ontario Hydro establishments at Fraserdale, Little Long Rapids, and Harmon. Private lumber roads provide access to the southeast corner of the area and to many parts of the area south of Highway 11. Most of these roads are newer than the most recent air photographs and their exact locations are not known. Information regarding serviceable lumber roads may be obtained from the Abitibi Power and Paper Company, the Spruce Falls Power and Paper Company, and the Ontario Department of Lands and Forests.

The Canadian National Railway transcontinental line follows Highway 11 from Cochrane to Hearst. The Ontario Northland Railway line from Cochrane to Moosonee provides a jumping off point for the northeast and west-central parts of the area.

Fixed wing aircraft are available at Cochrane, Kapuskasing, and South Porcupine; however, the number of lakes in the area of suitable size for float equipped aircraft is limited. Helicopters, available in Timmins, are by far the most economical means of access to many parts of the area.

PRESENT SURVEY

The present survey was conducted from May 15 to September 15, 1966. This was the first of a series of large scale, helicopter reconnaissance surveys undertaken by the Ontario

Department of Mines. The area was chosen as the geology was of immediate interest to the public because of the occurrence of the Kapuskasing-Moosonee aeromagnetic anomaly in the north-central part of the area, the presence in the area of a number of volcanic-sedimentary belts about which little was known, the occurrence of rare earth-bearing carbonatites in certain parts of the area and reported base metal occurrences in the Hurdman township area.

The fact that the area is readily accessible by road and railway, and that aviation gas is available locally, meant that pre-season planning could be confined to the organization of the field work rather that to problems of supply and accommodation. During the winter of 1965-66, D.D. Brown compiled all of the available data on the area and studied the air photographs to locate areas of outcrop. All outcrops visible on the air photographs were plotted on base maps and camp sites were chosen with proximity to outcrop areas in mind.

It is of interest to note that very little new outcrop was found from the air by helicopter which could not be seen on quarter-mile to one inch air photographs. In areas with heavy bush cover it is very difficult to spot small scattered outcrops from the air if they are not already visible on airphotos.

The field crew consisted of four staff geologists, fifteen geological assistants, and the helicopter support. E. J. Leahy and five assistants mapped that part of the area west of longitude 82°00'W and accessible by road from Highway 11.

G. Bennett, D.D. Brown, P.T. George, and ten assistants mapped the remainder of the area with helicopter support.

The mapping was accomplished by pace-and-compass traverses, canoe reconnaissance, and helicopter reconnaisssance. Field work was plotted on one mile to one inch air photographs and transferred to two mile to one inch base maps for preliminary publication. All previous geological mapping was verified before being plotted on the present maps.

A total of approximately 400 hours were flown using a Bell J-2 helicopter. Utilization of the helicopter time was approximately as follows:

(a) 50% geological reconnaissance

(b) 35% transportation of traversing parties and servicing of canoe reconnaissance parties.

(c) 10% systematic traversing of areas of little or no outcrop.

(d) 5% ferry time.

ACKNOWLEDGMENTS

The success of Operation Kapuskasing was in large part due to the excellent services provided by R. Huisson, R. De Blicquy, and G. Aust of Pegasus Airlifts, Burlington, Ontario.

J. Ramsden, P.Y. Robin, W.O. Karvinen, W. Moon, and J.R. Trusler acted as senior assistants, and L.C. Gobeil, D.J.C. Nugent, I.G. Ferguson, P.C. Walford, R. Szackrajuk, T. Moore, S.W. Burnie and R. Neils acted as junior assistants. B.J. Vander Kamp, R.A. Porter, and J.W. Redden were with the field crew for part of the summer.

Throughout the summer, accommodations for which the authors are grateful were supplied by the Abitibi Power and Paper Company, the Ontario Hydro Electric Power Commission, the Ontario Northland Railway, Spruce Falls Power and Paper Company and commercial operators.

Georgian Bay Airways supplied fixed wing aircraft support and radios, and maintained a radio schedule with the field party throughout the summer.

R. Balgalvis and D. Winters of the Preliminary Map Unit, Ontario Department of Mines, Toronto did much of the final work on the preliminary maps.

TOPOGRAPHY

The areal topography is essentially a plain of low relief sloping at 3 to 5 feet per mile towards James Bay from a maximum elevation of approximately 800 feet above sea level at the south boundary of the area. Locally the relief may be up to 100 feet along the major river valleys but in general the local relief is less than twenty-five feet.

Numerous major rivers drain the area, the more important ones being the Kattawagami, Kesagami, North French, Abitibi, Mattagami, and Missinaibi rivers, and their tributaries. Because of the low relief and low initial slope, the drainage system as a whole is poorly organized and everywhere the terrane is quite swampy.

The northern part of the area, underlain by the Paleozoic rocks (Figure 2) is a recently abandoned marine basin. The basin slopes imperceptibly towards James Bay, has very low relief, and is characterized by string bogs, muskeg, and sparse growth of scrubby jackpine and spruce. South of the basin area the topography is typical of a continentally glaciated area with thick overburden. The Pinard Moraine formed during the recession of the Wisconsin glacier occurs as an east-west trending ridge across the central part of the area. Other topographic features such as eskers, drumlins, and fluting are common in the area. The major rivers have cut deep gorges in the Pleistocene sediments, in many places eroding to bedrock, but as a whole the surface is poorly drained with relief less that 25 feet. Forest cover is variable in grade but there are some excellent stands of timber south of the Pinard Moraine.

NATURAL RESOURCES

The main concentration of population in the area is along Highway 11 between Cochrane and Hearst. Other centres of population are Ontario Hydro establishments, lumber camps, section houses along the Ontario Northland Railway, and in the summer months a commercial fishery operation is run at Kesagami Lake by some members of the Indian population from Moosonee.

Agriculture is of minor importance in the area, however, there are a few excellent farms in the Cochrane area and along Highway 11 between Cochrane and Hearst.

Timber resources are abundant in the area. The main areas of active lumber operations are in the southwest part of the area between Little Abitibi and Abitibi lakes, and immediately north and south of Highway 11 from Smooth Rock Falls to Hearst. There are extensive stands of timber between Smooth Rock Falls and Fraserdale which are readily accessible by Highway 807.

The major rivers are important sources of water power. The Ontario Hydro has dams on the Abitibi River at Abitibi Canyon and Otter Rapids, and on the Mattagami River at Little Long Rapids and Harmon. The Spruce Falls Power and Paper Company has dams at Smoky Falls on the Mattagami River and at Kapuskasing, on the Kapuskasing River. The Abitibi Power and Paper Company operates a dam at Island Falls on the Abitibi River. Other potential dam sites occur in the area, on the Missinaibi and Opasatika rivers.

Pike and pickerel are abundant in many of the lakes in the area and there are a number of excellent trout streams, in particular, the Onakawana River.

Moose are abundant throughout the area and were seen daily from the helicopter. Black bear were only seen a few times during the summer. Partridge and water fowl are abundant in the area during the summer months.

GENERAL GEOLOGY

Introduction

The regional distribution of rock units is shown in Figure 2. The thickness of overburden and amount of bedrock exposed is highly variable throughout the area. All known outcrop areas and all available data on thickness of overburden are indicated on the preliminary maps. Because of the paucity of large outcrops, the relationships between the various rock units are interpretative for the most part.

The bedrock in the area ranges in age from early Precambrian to Cenozoic (Table 1, Table of Formations). Six belts of Keewatin-type mafic volcanic, felsic volcanic, and sedimentary rocks occur in the area (Locations A,C,D,E,F,G, and H, Figure 2). A large belt of sedimentary rocks (G, Figure 2) occurs in the southwest part of the area. Much of the west-central part of the area is underlain by biotite-hornblende-quartz-feldspar gneiss and migmatite. The gneisses are interpreted as being of metasedimentary and metavolcanic origin. The grade of metamorphism varies within the Almandine Amphibolite Metamorphic Facies with some areas within the gneisses, immediately west of the Granulite Zone that occurs in the east-central part of the area approaching the Granulite Facies of metamorphism.

Granitic intrusive rocks, including granodiorite, quartz monzonite, granite, and granite pegmatite, form large batholiths, satellite stocks, and lit-par-lit injection layers in the gneiss complex. Generally the granitic rocks appear to be synorogenic, haveing been intruded during or shortly after the folding and metamorphism of the gneiss complex.

Mafic and ultramafic rocks intrude the volcanic-sedimentary belts and the gneisses. The age relation between these rocks and the granitic rocks is uncertain. East of Fraserdale a large gabbro body contains xenoliths of layered ultramafic rocks and is cut by dikes of serpentinite. This intrusion would appear to be post-gneissic folding.

Table 1 TABLE OF FORMATIONS

PHANEROZOIC	Cenozoic	Quaternary		Pleistocene and Recent deposits.
		UNCONFORMITY		
	Mesozoic	Lower Cretaceous or Upper Jurassic		Mattagami Formation
		UNCONFORMITY		
	Paleozoic	Post-middle Devonian		Lamprophyric and kimberlitic intrusions
		INTRUSIVE CONTACT		
		DEVONIAN	Upper	Long Rapids Formation
			Upper and Middle	Williams Island Formation
			Middle	Upper Abitibi River Formation Middle Abitibi River Formation (Moose River Formation) Lower Abitibi River Formation
			Lower	Sextant Formation
		DISCONFORMITY		
		Silurian		Undifferentiated
		UNCONFORMITY		
PRECAMBRIAN	Proterozoic	Carbonatite		
		INTRUSIVE CONTACT		
		Diabase		
		INTRUSIVE CONTACT		
		Carbonatite		
		INTRUSIVE CONTACT		
		Granulite Complex		
		FAULT CONTACT		
		Diabase		
		INTRUSIVE CONTACT		
		Granitic Rocks		
		INTRUSIVE CONTACT		
		Mafic Intrusive Rocks		Age Uncertain
		INTRUSIVE CONTACT		
	Archean	Migmatite-Metasedimentary-Metavolcanic Gneiss Complex		
		METAMORPHIC CONTACT		
		Mafic Volcanic-Felsic Volcanic-Sedimentary Rock Complexes		

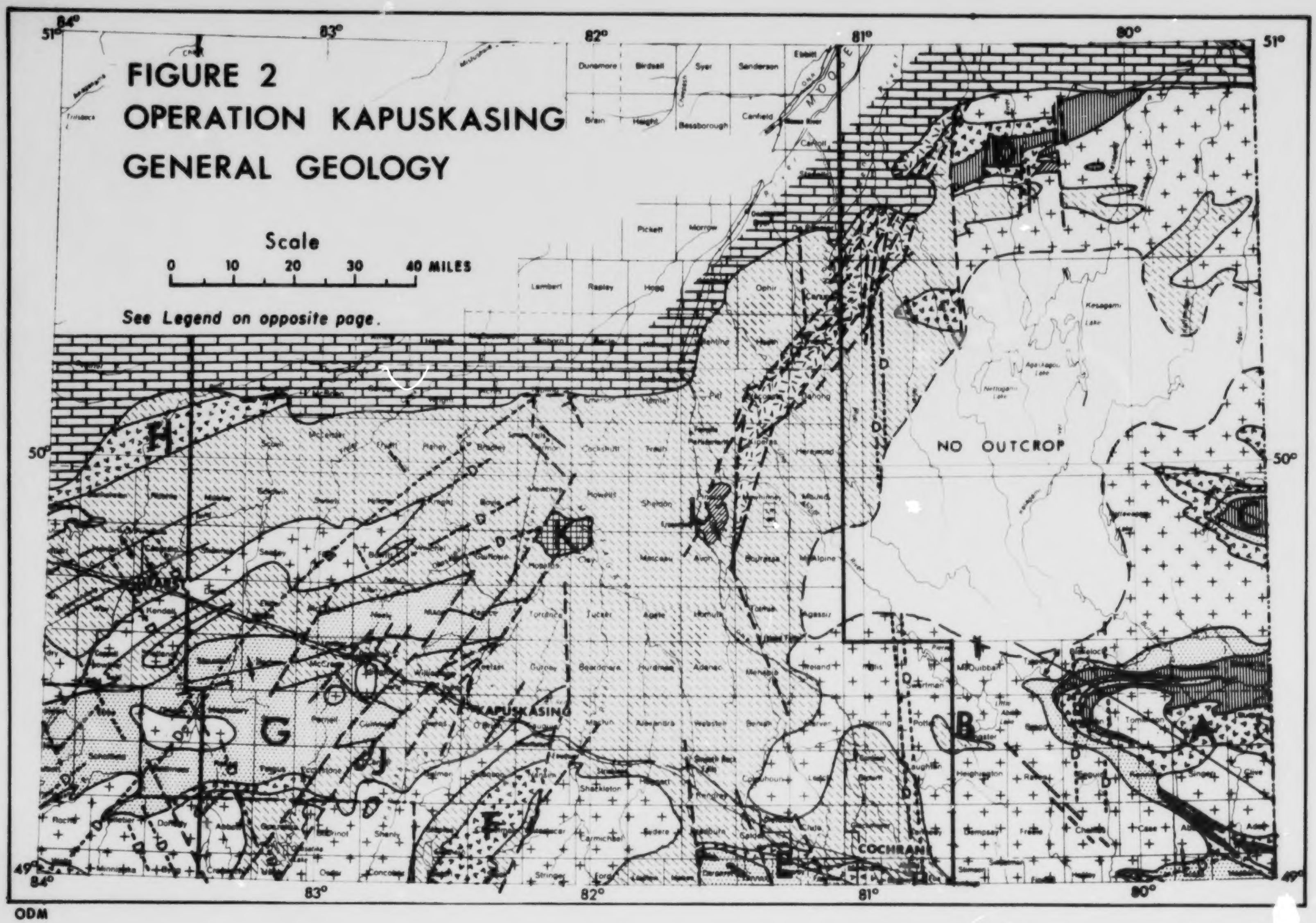


FIGURE 2
OPERATION KAPUSKASING
GENERAL GEOLOGY

See Legend on opposite page.

Scale
0
10
20
30
40 MILES
84°
83°
82°
81°
80°
51°
50°
49°
NO OUTCROP
KAPUSKASING
COCHRANE
Kesagami Lake
Nettogami Lake
Agaskagou Lake
MOOSE
A
B
C
D
E
F
G
H
J
K
ODM

LEGEND FOR GENERAL GEOLOGICAL MAP

▤	Paleozoic and Younger Rocks	▧	Gneiss Complex
- -D- - - -	Diabase Dike	░	Metasedimentary Rocks
▦	Carbonatite Complex	▥	Felsic Metavolcanic Rocks
+ +	Granitic Intrusive Rocks	▓	Mafic Metavolcanic Rocks
▨	Mafic Intrusive Rocks	— —	Major Fault
⁄ \	High grade Metamorphic Rocks: Hornblende-pyroxene Granulite	╱	Major Synclinal and Anticlinal Axial Trends

A	Kabika River Complex	**G**	Opasatika Complex
B	Sangster Lake Gneiss Complex	**H**	Pivabiska Complex
C	Detour Lake Complex	**J**	Cargill Complex
D	Partridge River Complex	**K**	Clay-Howells Complex
E	Cochrane Complex	**L**	Abitibi Canyon Mafic Complex
F	Saganash Complex		

ODM

High grade metamorphic rocks, consisting of hornblende-pyroxene - feldspar granulite occur in a northeast-trending zone in the east-central part of the map area. These rocks are in fault contact with the surrounding gneisses, metavolcanic, metasedimentary, and granitic rocks. Faulting along this zone probably occurred throughout Proterozoic time.

Diabase dikes of at least three different ages occur in the area. Fahrig et al (1965) have dated the north-trending dike swarm in the east central part of the area at 2485 million years, the northwest-trending swarm in the southwest part of the area at 2030 million years, and the northeast-trending dike in the southeast corner of the area at 1230 million years.

Carbonatite intrusions of two different ages occur in the area, in particular near the zone of north-northeast trending faults in the central part of the area. The two age groups are 1700 and 1000 million years old (Gittins, unpublished data); the younger carbonatites apparently representing the latest Precambrian event within the map area.

Paleozoic sedimentary rocks of Silurian and Devonian age outcrop in the north part of the area, in the James Bay Lowlands. The sedimentary rocks are intruded by post-Middle Devonian lamprophyre and kimberlite dikes and sills.

Mesozoic rocks of Lower Cretaceous or Upper Jurassic age outcrop in two limited basins in the north part of the area.

Unconsolidated deposits of Pleistocene to Recent age mantle most of the area. These deposits are of glacial, glaciofluvial, lacustrine, and marine origin.

PRECAMBRIAN

The following descriptions will indicate in a general way the regional nature of the rock types. Additional information regarding the relationships between the various rock types may be found in the section of the report dealing with the structural geology.

Archean

Volcanic and sedimentary rocks of Archean age are the oldest known in the area. These have been intruded by granitic rocks. The granitic rocks have been intruded by diabase dikes age dated at approximately 2485 million years (Fahrig et al 1965). This would indicate that the granitic rocks could be correlated with the late Archean, Kenoran orogeny.

Mafic to Intermediate Metavolcanics

Mafic to intermediate metavolcanics occur in all of the volcanic-sedimentary rock complexes in the area. In general, they are fine- to medium-grained, light to dark green, massive to schistose rocks, metamorphosed to amphibole, chlorite or epidote-bearing greenstones. As the degree of metamorphism increases, these rocks grade into coarse-grained amphibolites. Pillow structures are common but highly deformed; amygdules and flow top breccia were seen at a few localities.

Iron formation and thin sedimentary units occur intercalated with the volcanic assemblage. Associated with the iron formation in places are fine-grained, finely banded mafic, tuffaceous rocks.

Many of the amphibolite and amphibolitic gneiss zones in the Migmatite-Metasedimentary-Metavolcanic Complex are assumed to represent highly metamorphosed mafic volcanic rocks.

Felsic to Intermediate Metavolcanics

Felsic volcanic rocks of both flow-type and pyroclastic origin occur in the area. The flow-type rocks are aphanitic to fine-grained, massive to sheared, and light grey to grey-green in colour. The pyroclastic rocks vary in texture from fine-grained tuffs to coarse-grained, agglomerates with bombs and fragments up to 18 inches in diameter.

Graphitic material has been reported from some drill holes in the felsic to intermediate assemblage; in particular in the Noseworthy - Bradette township area.

Metasediments

The dominant sedimentary rock type in the area is greywacke. The greywacke is commonly fine-grained, massive to finely bedded, light to dark grey in colour, and consists of 10 to 20 percent chlorite, sericite, or biotite and 80 to 90 percent quartz, feldspar, and lithic fragments; quartz being the dominant constituent. As metamorphic grade increases the greywacke grades into the biotite-quartz-feldspar gneiss of the Migmatite-Complex.

Within the greywacke are zones of very fine-grained, dark grey, argillitic rocks. As metamorphic grade increases these rocks become phyllitic with needle-like amphiboles developing in layers.

Quartzitic layers are common within the greywacke sequence.

Amphibolitic rocks also occur within the metasedimentary sequence. The origin of these rocks is uncertain. They may represent metamorphosed mafic tuffs or simply a facies difference in the original sedimentary rock.

Arkosic sandstones occur southeast of Mattice on the Missinaibi River. These rocks outcrop between the greywacke and the hybrid granitic gneisses in that area. The similarity in appearance between the arkose and the gneissic rocks might suggest an unconformity rather than an intrusive contact. This would indicate the possibility of two ages of sedimentary rocks in the area, one approximately the same age as the metavolcanics, the other younger than the metavolcanics but pre-granite in age.

Iron Formation

Iron formation has been seen in surface showings and encountered in diamond drilling in the metavolcanics and metasediments in the area. The magnetite-bearing iron formation is characteristicly very siliceous and varies in grain size and texture from very fine-grained and finely banded to medium-grained with bands of quartzitic material up to one-foot across. Descriptions of some of the economically interesting iron formation are given under the heading "Economic Geology".

Migmatite-Metasedimentary-Metavolcanic Complex

The rocks included in this group display a wide range in composition and metamorphic structure and a detailed subdivision of the rock types was impossible at a reconnaissance scale of mapping. The general characteristics of the various subdivisions mapped are given below.

The biotite-quartz-feldspar and hornblende-quartz-feldspar gneisses display similar gradations in their compositional, textural, and structural characteristics.

They vary in composition from biotite schist or amphibolite layers separated by massive quartz-feldspar layers to regularly banded gneisses of biotite or hornblende granite composition.

In many occurrences the texture has a definite paragneissic appearance with very regular, fine banding, and a distinctly sugary texture.

As the grain size increases, the gneisses commonly take on the appearance of a hybrid granitic gneiss with highly contorted banding. When this textural feature occurs on a limited scale for example in a single layer within otherwise regularly banded gneiss the rock-type is included in the biotite or hornblende gneiss classification. Garnet is common in the gneisses, occurring as porphyroblasts or as equigranular, generally euhedral to subhedral crystals.

Amphibolite occurs as distinct bands and as extensive zones within the biotite and hornblende gneisses. The large stratiform zones of amphibolite are believed to represent mafic metavolcanic or metagabbroic rocks.

Quartz-mica schist consisting dominantly of quartz with minor sericite or biotite occurs within the gneiss complex and is believed to be of sedimentary origin.

Lit-par-lit injections of fresh, massive, granitic material in stratiform layers in the gneiss complex are common. The proportion of injected granitic material may be as great as 90 percent in any particular small outcrop but the rock would still be classed as part of the gneiss complex if the contacts between the gneissic and granitic layers are sharp. The main reason for this was that in the few good exposures perpendicular to the strike of the gneisses, it was not uncommon to find an occasional granite layer up to 200 feet wide in a section where the dominant structure would be alternating layers of lit-par-lit granite and gneiss less than one foot thick.

The sharp, intrusive nature of the contact between the lit-par-lit granite and the gneissic layers is in distinct contrast to the relationship between the gneissic and granitic layers in the hybrid granitic gneiss. In the hybrid granitic gneiss, the contacts are gradational between the granite and the gneiss and the granite definitely appears to have been generated in situ. As the amount of granitic material increases in the hybrid gneisses the gneissosity becomes highly contorted and many blocks of relatively regularly layered gneiss are found floating in the hybrid gneiss.

Granulite Complex

The high grade metamorphic rocks of the Granulite Zone occur in a northeast-trending fault wedge in the north-central part of the map area. Similar rocks occur in Macvicar township southeast of Kapuskasing.

The rocks are characteristically massive to faintly gneissic and consist of variable quantities of hypersthene, hornblende, augite, plagioclase (An 35-70), microcline, quartz, garnet, and rarely biotite. Magnetite is ubiquitous. The plagioclase commonly has a yellowish-green, waxy appearance and in some cases, complete replacement of plagioclase by scapolite has been observed under the microscope. The quartz is generally highly strained and commonly displays a cataclastic texture.

When more detailed mapping is carried out it should be possible to classify the granulitic rocks into at least three groups: feldspathic to siliceous, possibly of metasedimentary origin; mafic, either of mafic meta-intrusive or mafic meta-extrusive origin; and charnockitic, of uncertain origin. No granitic rocks of definite intrusive origin were mapped in contact with the granulites. The rocks are probably of Archean age but were faulted into place during Proterozoic time.

Intense mylonitization along fault zones bordering the granulite complex has resulted in a black, dense, cherty appearance to the rocks. In thin section these rocks consist of very fine-grained, cataclastic quartz and feldspar in an aphanitic, dark brown, matrix. Fine- to coarse-grained augen of plagioclase are present in some samples.

Aphanitic to medium-grained, black, trap dikes occur in the mylonite zones. In thin section these rocks consist of medium-grained augite phenocrysts (some of the crystals are rimmed with hornblende) in a very fine-grained matrix of plagioclase (An_{60}), hornblende, and biotite, with minor secondary calcite and magnetite. The rock could be classed as a biotite gabbro.

The age of the rocks of the granulite zone is uncertain; however, they are probably Archean, representing highly metamorphosed volcanic and sedimentary rocks that were faulted into place during Proterozoic time.

It should be noted that although the diabase dikes in the area are offset or terminated by the faulting, none are found within the granulite zone.

Felsic Intrusive Rocks

The rocks mapped as felsic intrusions display a wide range in composition and texture and no attempt was made towards a detailed subdivision due to the scale of mapping. The rocks range from granite to quartz monzonite to granodiorite with textures varying from fine-grained to pegmatitic, massive to foliated with schlieren or fragments of gneissic material. Graphic granite is very common in the area.

The felsic rocks occur as batholithic intrusions and related satellite stocks, as lit-par-lit injection layers in the gneiss complex, and as dikes and stringers in the gneisses, metasediments and metavolcanics. Ptygmatically folded granitic stringers are common in the area and appear to be older than the fresh granitic dikes and stringers.

Proterozoic

The Proterozoic rocks in the area are all of igneous intrusive origin with the possible exception of a flat-lying, brown, amygdaloidal basalt, intersected in one diamond drillhole in Kilmer township, northwest of Coral Rapids. This basalt was interpreted as being of Keweenawan age (Satterly in Martison, 1952, p. 156) because of its physical characteristics.

Diabase

Fahrig et al (1965) has dated three swarms of diabase dikes in this region of the Canadian Shield at 2485, 2030, and 1285 million years old with general strike trends of north, north-northwest, and northeast respectively. The dikes within the map-area fall into three statistically separable strike trends of N10^{o}W, N40^{o}W and N30^{o}E. No age determinations are available but in general field data would support the same relative age relationships between the three different strike trends as that suggested by Fahrig et al (1965).

There is a definite geographical zoning with respect to the different groups of dikes. The oldest, north-trending swarm dominates the area to the southeast of the granulite zone, the north-northwest trending group dominates the southwest corner of the map-area, and the main exposures of the northeast-trending swarm are to the west of the granulite zone; they do however occur in the southeast corner of the area as well. The age relation between the north-striking and the northwest-striking dikes is uncertain, but both are older than the northeast-striking dikes.

No diabase dikes similar to the above types, that are typically fine- to coarse-grained, gabbroic to diabasic textured rocks composed of plagioclase (An 50-60), augite, olivine or quartz, magnetite, and minor pyrite, have been found cutting the granulite zone.

Carbonatites

At least four carbonatite intrusions and related biotite-pyroxene-amphibole-carbonate rock, pyroxenite, amphibolite, and aegirine syenite occur in the area. Two ages of carbonatite are recognized, one early Proterozoic, the other late Proterozoic. The general form of the carbonatite intrusions is based on diamond drill information and indications are that the carbonatites occur as tabular, steeply dipping sheets surrounded by a zone of biotite-pyroxene-amphibole carbonate rock, and amphibolite or pyroxenite. Alkalic syenite that is believed to be of late Proterozoic age (younger than the northeast-trending diabase dikes) surrounds the Clay-Howells complex.

Two carbonatite complexes, the Cargill and the Clay-Howells, intrude the gneiss complex. Two other carbonatites occur within the granulite zone on the Consolidated Morrison exploratory license area.

The carbonatite complexes all display close spatial relationships to major northeast-striking shear zones.

A uranium-thorium bearing carbonate vein at Otter Rapids on the Abitibi River may also be a carbonatite. The vein which is now submerged due to flooding behind the hydro dam was described by Hogg (1947) as follows:

> "The veins occur in a pronounced north-striking zone of fracture about 25 to 30 feet wide, that cuts across the gneissosity at right angles. The carbonate is a pale grey-green colour and crystalline with a fine granular texture--probably impure dolomite--specularite is common, pyrite and chalcopyrite are sparsely present".

No uranium or thorium-bearing minerals were identified.

A carbonate zone in Teetzel township approximately ten miles north of Kapuskasing may also be of carbonatite origin.

More detailed descriptions of the individual carbonatites will be found in the "Economic Geology" section of this report.

Mafic Intrusive Rocks

Gabbroic to pyroxenitic intrusive rocks of generally indeterminate age cut both the volcanic-sedimentary and the gneiss complexes. Rock exposure is limited or totally lacking around many of these intrusions but diamond drilling and aeromagnetic data indicate a body of considerable size in many cases.

A short description of three of these intrusions will suffice to show their general characteristics.

(a) Abitibi Canyon Mafic Complex:

The rocks of the mafic complex (Figure 2, Location L) are exposed in the gorge below the dam at Abitibi Canyon and along the Abitibi River and its tributaries south of the dam. The size of the intrusion is based on aeromagnetic data.

The rocks exposed below the dam consist of fresh, massive, medium-grained, equigranular, dark grey gabbro containing inclusions of apparently layered mafic intrusive material. The gabbro consists of clinopyroxene, plagioclase (An_{47}), olivine, biotite, magnetite and apatite.

The fresh, massive nature of the rock would strongly suggest that it is at least post-gneissic folding in age and thus may be of Proterozoic age.

(b) North French River Pyroxenite

The pyroxenite exposed on the North French River (81°04'W, 50°17'N) is reported to contain finely disseminated millerite (Gaucher 1966, p. 190). The pyroxenite is dark green, medium- to coarse-grained, and massive with zones of fracture and shearing containing serpentine stringers. Some zones are inequigranular with pyroxene crystals up to 1 inch across. In thin section, the rock consists dominantly of clinopyroxene with finely disseminated blebs of yellow sulphide (unidentified). Sulphides, magnetite, chlorite, and calcite comprise approximately 10 percent of the rock whereas amphibole and olivine are minor constituents. In some samples the pyroxene is highly altered to serpentine.

The pyroxenite is possibly of Archean age as it is cut by granitic stringers and is quite sheared, fractured and altered, a feature uncharacteristic of the majority of the Proterozoic rocks of the area.

(c) An outcrop of massive to sheared mafic rocks occurs east of Highway 807 near the Abitibi River ($81^{\circ}31'$W, $49^{\circ}44'$N). The rock varies in texture from massive, medium-grained, equigranular, to schistose to phyllitic and aphanitic.

In thin section the medium-grained, massive phase of the rock consists of zoned laths of plagioclase (An 35-40) with ophitic pyroxene rimmed by hornblende. Both the pyroxene and hornblende are secondarily altered to chlorite. Many of the plagioclase laths are highly altered to very fine-grained quartz and sericite. Quartz, chlorite, magnetite, and sericite are present in small amounts.

Field relationships are very indefinite but gneissic rocks immediately to the north and south display similar structural trends. It cannot be definitely stated whether or not these rocks are of metamafic intrusive or metamafic extrusive origin.

Similar problems were encountered in other parts of the area. In the Detour Lake Complex (Figure 2, Location C) some of the rocks interpreted as mafic metavolcanics may be of intrusive origin. On the other hand in the Partridge River area (Figure 2, Location D) some of the material mapped as mafic intrusive rocks may be coarsely recrystallized mafic metavolcanics.

PALEOZOIC AND MESOZOIC

Introduction

The general stratigraphy and areal distribution of stratigraphic units have been summarized by Nelson and Johnson (1966) and by Martison (1952). These authors give detailed descriptions of the stratigraphic units and present detailed bibliographies . Interested parties may obtain additional information from these sources. Operation Winisk, a comprehensive study of the Hudson Bay Lowlands, is to be started during the summer of 1967 by the Geological Survey of Canada.

Much of the northern part of the map-area is underlain by flat-lying to gently dipping Paleozoic and Mesozoic rocks. The rocks are poorly exposed and during the present survey the majority of the time was spent on the Precambrian rocks, and for the Paleozoic and Mesozoic rocks, only that information which has not been presented in previous reports is described in detail below.

Stratigraphy

A generalized stratigraphic column of the Paleozoic and Mesozoic rocks indicating their ages, lithologies, maximum known thicknesses, and correlation with Paleozoic rocks of southern Ontario is presented in Figure 3. Figure 4 presents the areal distribution of the various stratigraphic units.

Paleozoic

The oldest Paleozoic rocks within the area are Silurian

FORMATION (and Author)		AGE	LITHOLOGY	MAXIMUM OBSERVED THICKNESS (feet)	CORRELATION	REMARKS
MATTAGAMI FM. (Keele, 1920)		Late JURASSIC or Early CRETACEOUS	Continental sand, clay, lignite.	170' Onakawana	Uncertain	Outcrops known only in southernmost parts of Hudson Bay Lowland.
			UNCONFORMITY			
LONG RAPIDS FM. (Savage and Van Tuyl, 1919)		Late DEVONIAN	Bituminous shale, grey calcareous clay, shale.	285' Onakawana	Kettle Point Fm., Ontario	Dominantly Shale
WILLIAMS ISLAND FM. (Kindle, 1924)		Late Middle or Early Late DEVONIAN	Limestone, grey and red shale, gypsum.	416' Mike Island	Hamilton Fm., Ontario	Dominantly Shale and Limestone.
ABITIBI RIVER FM. (Savage and Van Tuyl, 1919)	Upper	Middle DEVONIAN	Fossiliferous grey limestone.	48' Grand Rapids	Detroit River and Dundee Fms., Ontario	
	Middle (MOOSE RIVER FM., Kindle, 1924)		Limestone, gypsum, shale, sandstone.	291' Mike Island		Gypsum common.
	Lower		Fossiliferous cherty limestone, some sandstone.	131' Mike Island	Bois Blanc Fm., Ontario	
			GRADATIONAL CONTACT			
SEXTANT FM. (Savage and Van Tuyl, 1919)		Early (?) DEVONIAN	Continental sandstone, arkose, shale, conglomerate.	157' Coral Rapids	Uncertain	Limited to southernmost part of Hudson Bay Lowland.
Undifferentiated SILURIAN		SILURIAN	Dolomite, limestone, red and green siltstone and shale.	Uncertain	Uncertain	Not exposed within map area, but assumed to underlie parts of the area.

FIGURE 3 Summary of principal data relating to the Paleozoic-Mesozoic succession in the OPERATION KAPUSKASING AREA (Modified after Nelson and Johnson 1966, and Martison et al 1952)

in age and consist of limestone, dolomite, and sandstone. The Silurian has not been subdivided whereas the Devonian rocks have been subdivided into five formations.

The basal Devonian Sextant Formation consists dominantly of continental-type, red to green, clastic sediments; sandstone, shales, and arkoses. The contact with the overlying Abitibi River Formation is gradational and is probably time-transgressive throughout the area. The Lower Abitibi River Formation consists of fossiliferous, cherty limestones, and some sandstone. The Middle Abitibi River Formation consists essentially of an evaporitic sequence of non-fossiliferous limestone, shale, and gypsum. The Upper Abitibi River Formation consists of fossiliferous limestones that are overlain by the non-fossiliferous limestone and calcareous shale of the Williams Island Formation. The youngest Devonian rocks are dominantly shales, the Long Rapids Formation.

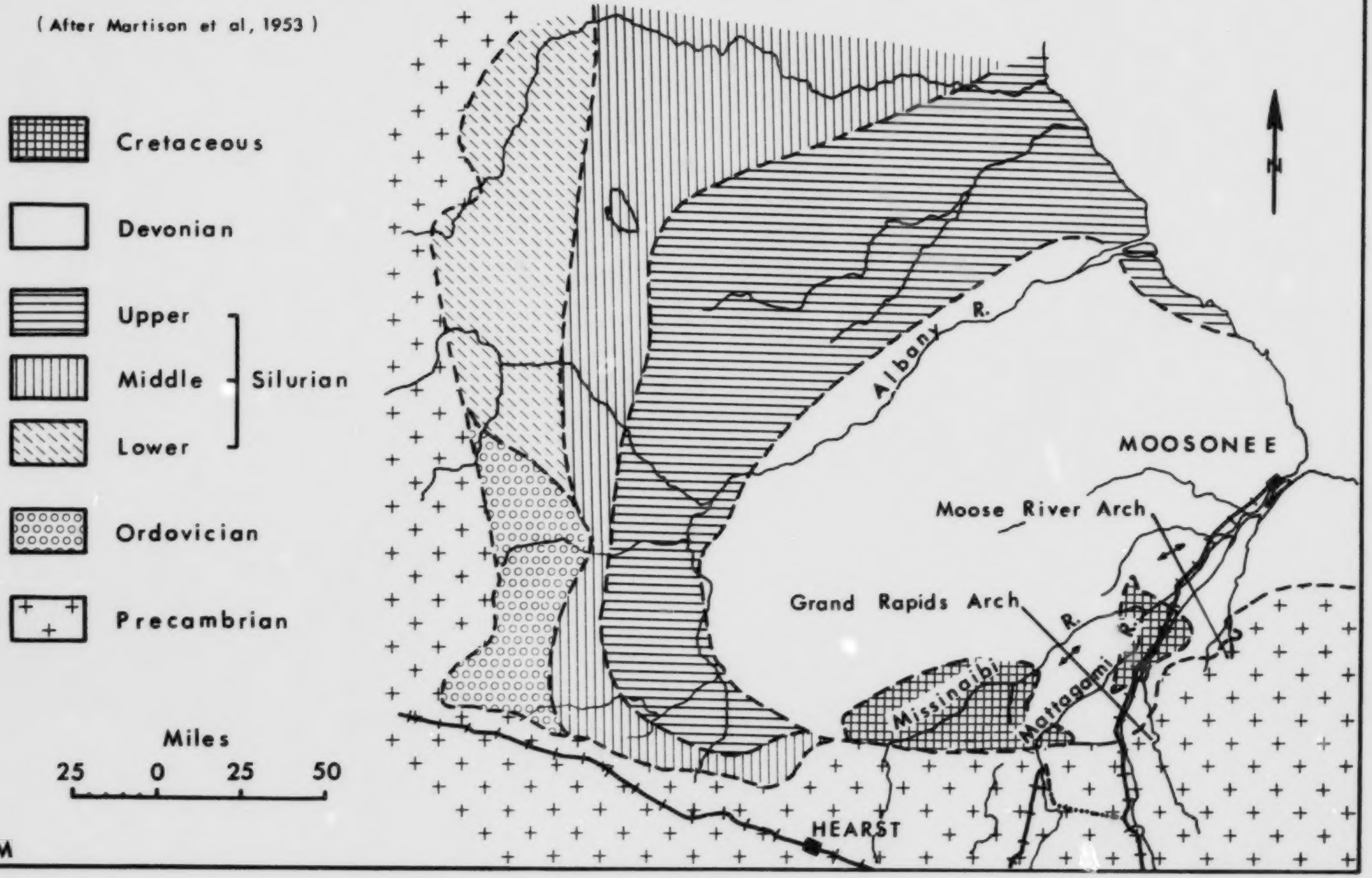
In the Otter Rapids - Coral Rapids area of the Abitibi River, the Ontario Hydro Electric Commission has drilled a number of holes. Of considerable interest are the intersections of lamprophyric and kimberlitic intrusive rocks that are described in detail below. The stratigraphy in this part of the area is illustrated in Figures 5 and 6.

Mesozoic

The Paleozoic rocks are unconformably overlain by Mesozoic sedimentary rocks of Upper Jurassic or Lower Cretaceous age. These rocks are limited in areal extent and were apparently

FIGURE 4 — GEOLOGY OF THE JAMES BAY LOWLAND

(After Martison et al, 1953)


Cretaceous
Devonian
Upper
Middle
Lower
Silurian
Ordovician
Precambrian
Miles
25
0
25
50
N
Albany R.
MOOSONEE
Moose River Arch
Grand Rapids Arch
Missinaibi R.
Mattagami R.
HEARST

ODM

deposited in a shallow, fresh water lake at the base of the Precambrian escarpment. The Mesozoic rocks consist of unconsolidated quartz sand with a kaolin matrix containing lenticular beds of variously coloured fireclays, and dark grey fireclay with interbedded lignite. The lignite is mainly confined to a limited basin of deposition in the area of Onakawana whereas the quartz sands occur dominantly to the southwest, marginal to the Precambrian escarpment. The Grand Rapids Arch (Figure 4) may have acted as a barrier to sediment transportation giving rise to the two different facies of Mesozoic rocks.

Considerable interest has been shown in the Onakawana lignite deposits and in December of 1966, the Ontario government granted a license to Alberta Coal Limited of Calgary for the exploration of lignite in a 375-square mile area near Onakawana. A detailed description of the Onakawana deposits may be found in Dyer (1928).

Two changes in the Paleozoic - Precambrian contact as shown on previous maps should be noted:

(a) In the northeast part of the map-area the contact has been shifted considerably to the north.

(b) In the west-central part of the area, east of the Missinaibi River, the contact has been shifted to the south to include a sequence of red siltstones and shales, possibly Sextant Formation, that is exposed along a small tributary of the Missinaibi River.

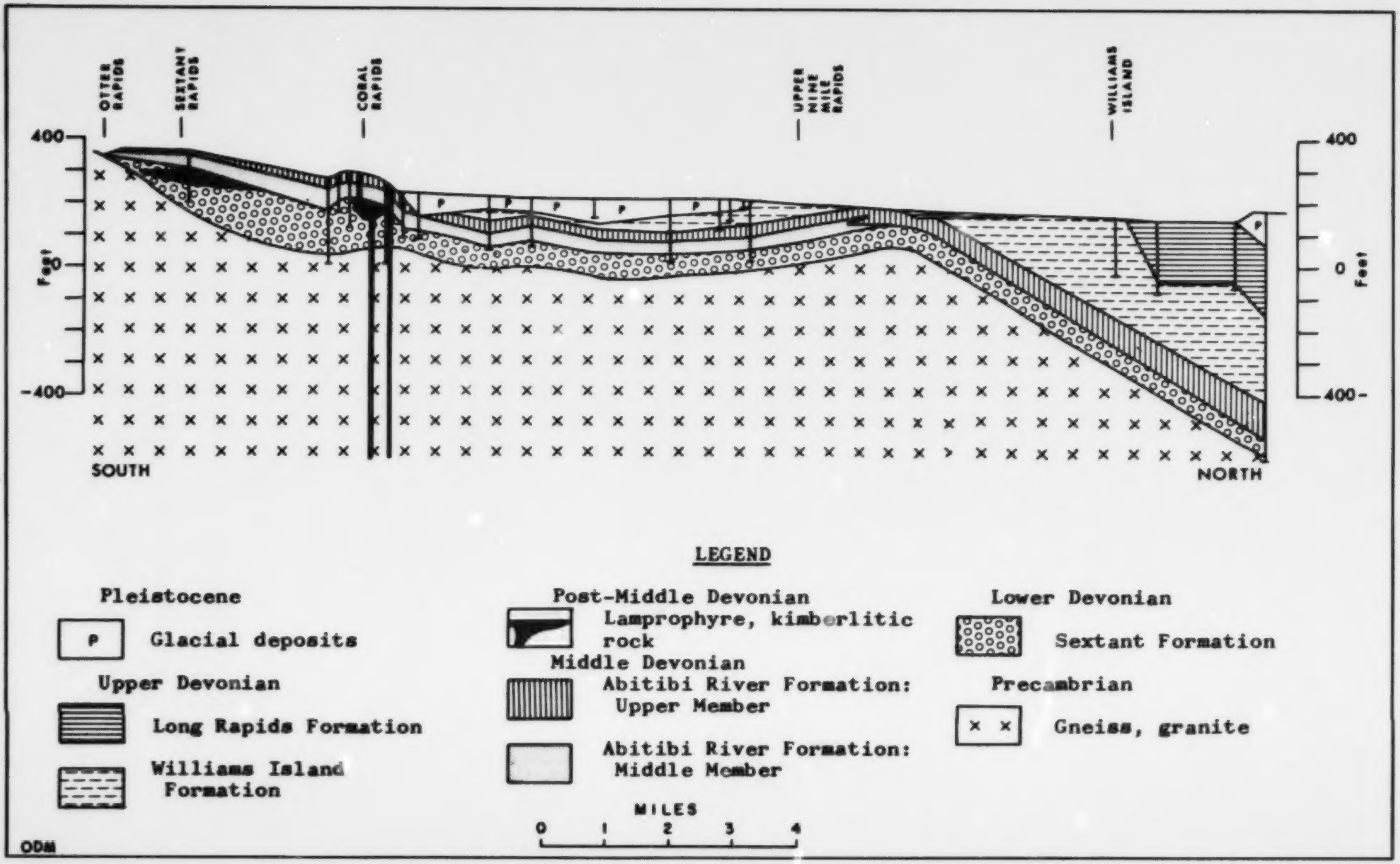

OTTER RAPIDS
SEXTANT RAPIDS
CORAL RAPIDS
UPPER NINE MILE RAPIDS
WILLIAMS ISLAND
400
0
-400
Feet
SOUTH
NORTH
P
LEGEND
Pleistocene
P Glacial deposits
Upper Devonian
Long Rapids Formation
Williams Island Formation
Post-Middle Devonian
Lamprophyre, kimberlitic rock
Middle Devonian
Abitibi River Formation: Upper Member
Abitibi River Formation: Middle Member
Lower Devonian
Sextant Formation
Precambrian
× × Gneiss, granite
MILES
0 1 2 3 4
ODM

Figure 5— Geological section along the Abitibi River (modified from sections of Ontario Hydro)

Structure

The southern limit of deposition of Silurian and Devonian rocks was controlled by a generally east-west striking Precambrian escarpment. On the Missinaibi and Mattagami rivers there is definite evidence that this is a fault scarp as proposed by Martison (1952, p. 52).

Minor folding, with the beds undulating in all directions but maintaining an overall dip of 3 to 5 degrees towards the centre of the Devonian basin (see Figure 4), is common and is undoubtedly due to supratenuous folding over irregularities in the Precambrian basement topography.

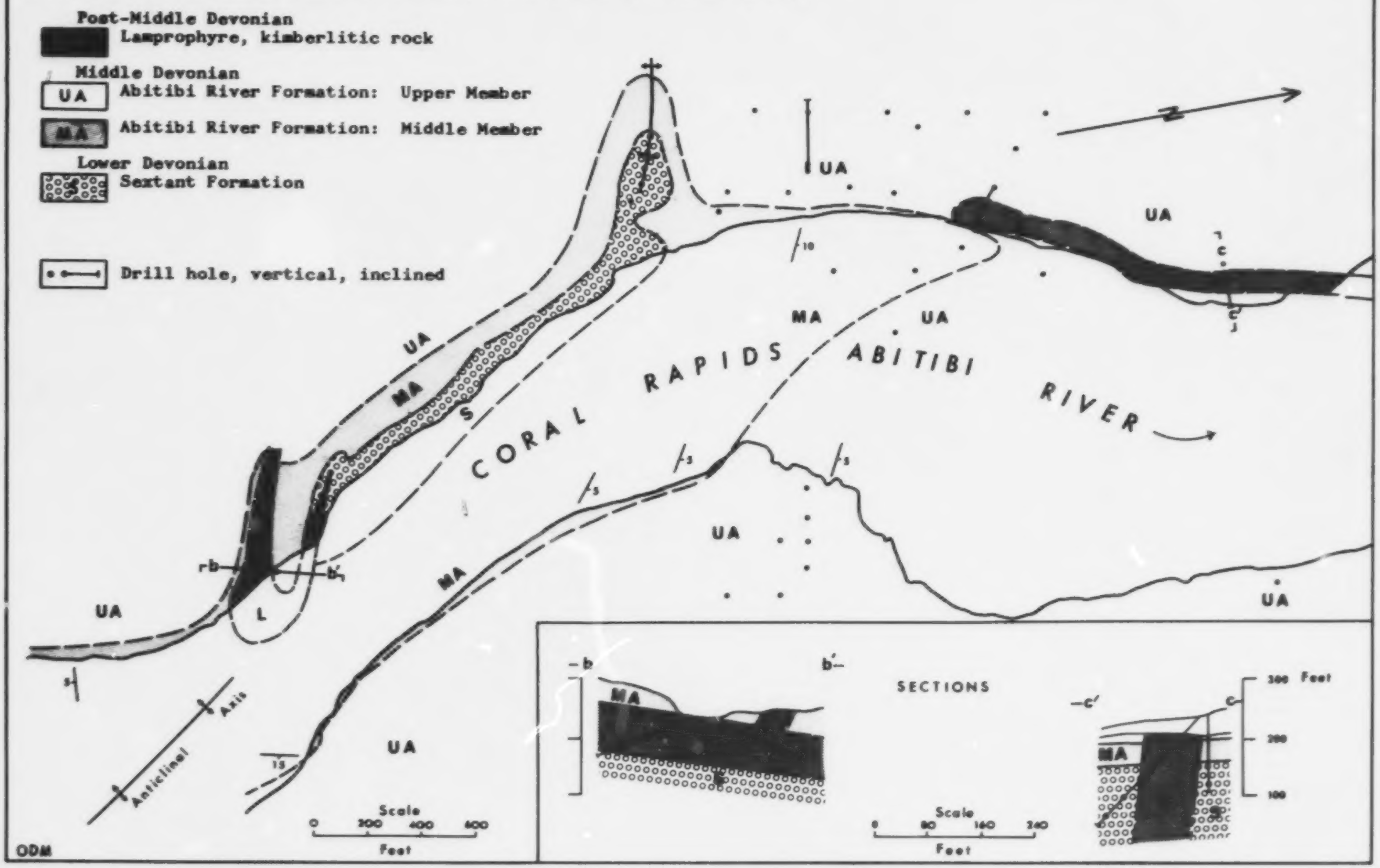
Two regional arches, the Grand Rapids and Moose River Arches, have been described (Martison 1952, p. 54) and are located on Figure 4. Local folding has occurred in the Otter Rapids - Coral Rapids area and has been ascribed to the intrusion of the post-Middle Devonian lamprophyric and kimberlitic dikes and sills.

Post-Middle Devonian Intrusions

Post-Middle Devonian, ultramafic, lamprophyric and kimberlitic sills and dikes intrude the Sextant and Abitibi River formations at Coral Rapids as shown in Figures 5 and 6. Their age relationship to the Williams Island and Long Rapids formations is not known.

Sextant Rapids on the Abitibi River is formed by a lamprophyre sill, about 60 feet thick, in the Sextant Formation.

Figure 6-Map of lamprophyre and kimberlitic intrusions, Coral Rapids, Abitibi River, Valentine Township (modified from plans by Ontario Hydro)


Post-Middle Devonian
Lamprophyre, kimberlitic rock
Middle Devonian
UA
Abitibi River Formation: Upper Member
MA
Abitibi River Formation: Middle Member
Lower Devonian
S
Sextant Formation
Drill hole, vertical, inclined
N
UA
MA
S
L
b
b'
c
c'
10
5
15
CORAL RAPIDS
ABITIBI RIVER
Anticlinal Axis
Scale
0
200
400
600
Feet
SECTIONS
Scale
0
80
160
240
Feet
300 Feet
200
100
ODM

The sill extends across the river as a sheet, and dips a few feet per mile to the north.

O. E. Le Roy (1902, p. 237A) described the lamprophyre as follows:

> "The hand specimens represent a very dark, almost black augite lamprophyre of a type closely allied to the monchiquites The section consists of aggregates of calcite and serpentine as pseudomorphs after olivine; and pale-brown and pink idiomorphic augites in a groundmass of augites, shreds of biotite, calcite, fluorite, magnetite, and a fibrous zeolite."

The zeolite, which was identified as thomsonite by Walker (1932) forms radial fibrous aggregates one centimetre in diameter.

At the head of Coral Rapids, 2 miles downstream from Sextant Rapids, a lamprophyre sill about 60 feet thick is exposed on the west bank of the Abitibi River and extends along the contact between the Sextant Formation and middle member of the Abitibi River Formation (Fig. 6). Megascopically, the lamprophyre is a grey, fine-grained rock with visible phlogopite. In thin section, it consists of phenocrysts of olivine (Fo_{90} Fa_{10}), radiating fibrous zeolite (thomsonite) in a very fine-grained, felted groundmass of melilite (?), magnetite, and unidentified minerals.

A composite dike composed of lamprophyre and a kimberlitic rock is exposed at the foot of Coral Rapids on the west bank of the Abitibi River and has been intersected by several Ontario Hydro drill holes. The dike is 80 to 100 feet wide, is at least 1400 feet long, strikes N30°E, and has a vertical dip (Figure 6). The lamprophyre forms the southern half of the dike and is about 100 feet wide. About 20 feet of the eastern edge of the dike at the river's edge consists of kimberlitic rock which appears to intrude the lamprophyre; the contact between the lamprophyre and kimberlitic rock is sharp. The lamprophyre is similar in colour, but is finer-grained, than the Sextant lamprophyre, and in thin section it contains 25 percent serpentinized olivine phenocrysts and rare, zoned, clinopyroxene phenocrysts in a very fine-grained felted groundmass of clinopyroxene, saponite (?), chlorite, carbonate, magnetite and other unidentified minerals. The kimberlitic rock which is 80 feet wide forms the northern part of the dike.

Drill sections show that the dike rises from the Precambrian basement and intrudes more than 50 feet of Sextant Formation, 35 feet of the middle member and 20 feet of the upper member of the Abitibi River Formation. No vertical offset was found along the dike.

The kimberlitic rock is pale green, moderately soft, and exhibits a fragmental texture. The fragments form about ten percent of the rock, are rounded dark green microcrystalline basaltic fragments 1mm. to 2cm. in diameter, xenoliths of rounded, altered granitic basement rocks 1 to 2 cm. in diameter, and rounded quartz grains, and cleavage fragments of plagioclase, microcline, and colourless kyanite. W. W. Moorhouse (written commumication, 1966) describes the fragments as follows:

> "The most common fragments are basaltic in texture, are rounded, although some have re-entrant angles. The basalt consists of phenocrysts of olivine, entirely replaced by serpentine, a green-brown mineral with the birefringence of mica, and carbonate. The phenocrysts are enclosed in serpentine, carbonate, and cloudy material enclosing small lath shaped pseudomorphs of plagioclase (or melilite?) now composed of chlorite or serpentine."

In thin section the matrix is composed of 12 percent serpentinized clinopyroxene, 3 percent phlogopite, and unidentified zeolite; 10 percent calcite; 8 percent magnetite; 2 percent ilmenite; and 65 percent very fine-grained, clay minerals with an olive-green to yellow birefringence. X-ray diffraction studies show that the clay minerals are mainly montmorillonite, with minor amounts of serpentine and chlorite. The montmorillonite contains calcium as the interlamellar cation and is probably saponite. The ilmenite was identified by x-ray diffraction, and semiquantitative electron microprobe analysis provided by the University of Toronto gave a large amount of magnesium and iron, but only a minor amount of titanium. In places approximately spherical fragments of the matrix 1 to 2 millimetres in diameter are separated by interstitial calcite. Calcite also occurs with serpentine as pseudomorphs after idiomorphic olivine or pyroxene, and some calcite forms thin veinlets up to 5 millimetres wide.

Brown et al (1967) compare the chemistry and mineralogy of the Coral Rapids intrusions with data from known kimberlite intrusions and concluded that "The Coral Rapids kimberlitic rock resembles other kimberlites in texture, colour, mineralogy, and softness, and to a certain extent in chemistry. However, because it apparently lacks the pyrope and chrome-diopside essential to the definition of kimberlite it has been called a kimberlitic rock rather than kimberlite."

CENOZOIC

Pleistocene

Introduction

The following summarizes, the available information regarding the Pleistocene history of the Kapuskasing area. The interpretation is based on previously published Pleistocene descriptions and data about the thickness of overburden as indicated from diamond drilling by mining companies. Much of the map-area is covered by overburden of glacial, glacialfluvial and lacustrine origin. Thicknesses are indicated on the preliminary maps and are generally less than 100 feet but may be as great as 300 feet at some localities. The most recent studies of the Pleistocene deposits of the area have been made by Boissonneau (1965, 1966), Terasmae and Hughes (1960), and Hughes (1956, 1961). Other observations have been made by various people over the years and pertinent references and data are quoted below.

Stratigraphy

Descriptions of the Pleistocene stratigraphy are scattered throughout the literature. The most important sections are located on Figure 7, and references are given. Figure 8, illustrates the general stratigraphy of the Pleistocene and Recent deposits north and south of the Pinard Moraine (see Figure 7) and indicates a tentative correlation of the local stratigraphy to the Pleistocene stages and sub-stages.

In the northern part of the area the Pleistocene and Recent deposits may be subdivided into eight units. The oldest Pleistocene deposits consist of till, glaciofluvial sand, and gravel. At one locality on the Missinaibi River, Terasmae and Hughes (1960, p. 1) have subdivided this unit into the Lower and Middle Till, both of which underlie the Missinaibi Beds. The Missinaibi Beds are a series of interglacial deposits consisting of organic silt, clay and peat layers. The locations of exposures of interglacial sediments of this type are indicated in Figure 7. The Missinaibi Beds have been radiocarbon dated at an age greater than 38,000 years, possibly as old as 53,000 years (Terasmae & Hughes, 1960, p. 11). Overlying the Missinaibi Beds is the Upper Till of Terasmae and Hughes (1960) which in turn is overlain by marine sediments. Directly north of the Pinard Moraine at Worobec Lake in Kineras township (see Figure 7) the interglacial beds are absent and the Upper and Middle Tills are separated by a unit consisting of grey silt and fine sand. In some parts of the area, freshwater lacustrine deposits have been described overlying the Upper Till and older Pleistocene deposits. Dyer (1933) describes a younger till, overlying the marine sediments at Moose Factory, approximately 15 miles north of the map-area. No evidence has been seen to establish this unit within the Operation Kapuskasing map-area.

In the southern part of the area, the basal Pleistocene consists of substratified poorly sorted glacial debris and

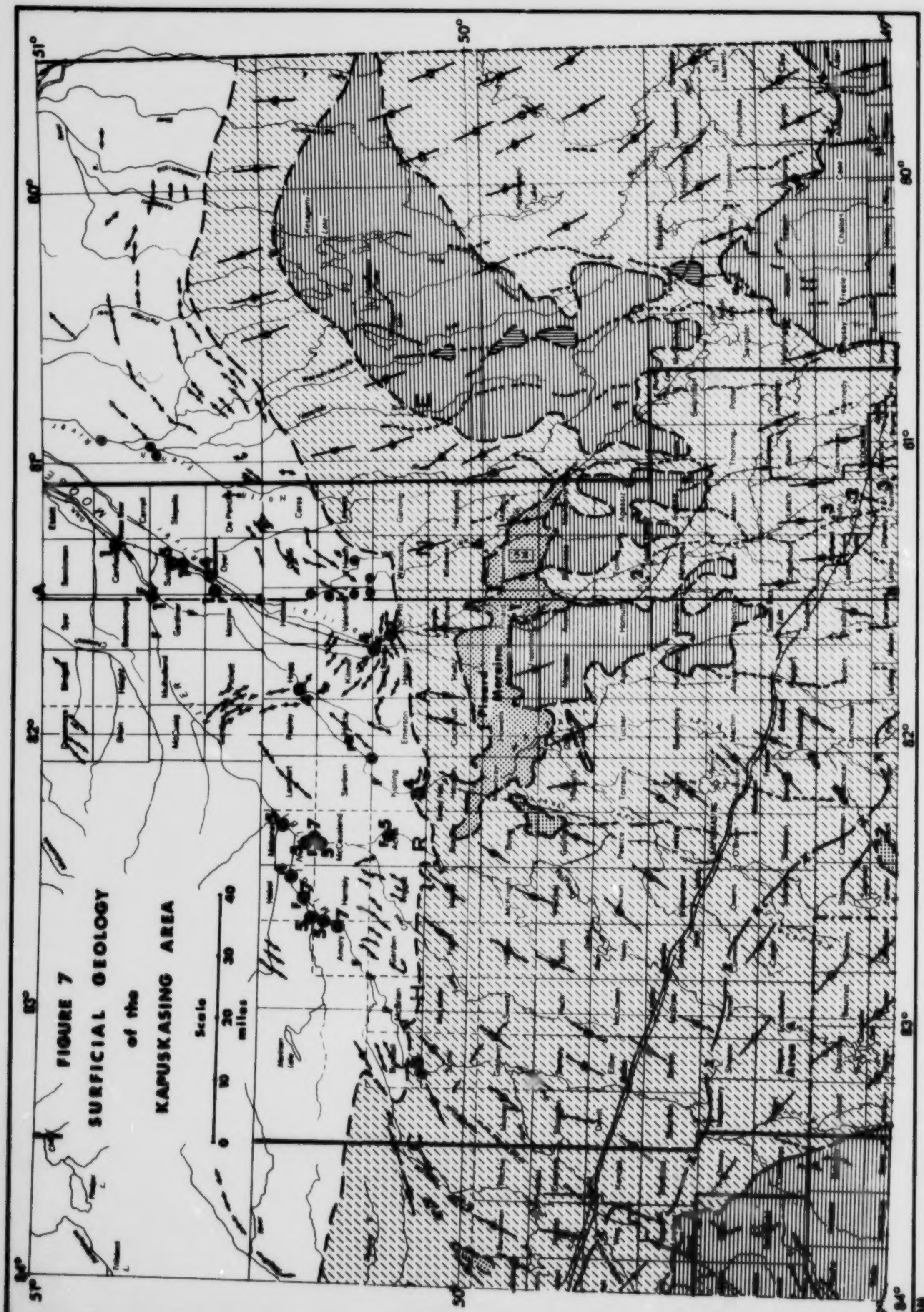


FIGURE 7
SURFICIAL GEOLOGY
of the
KAPUSKASING AREA

Scale
0
10
20
30
40
miles
51°
50°
49°
84°
83°
82°
81°
80°
Kesagami Lake
Challies
Freele

LEGEND

SURFICIAL GEOLOGY of the KAPUSKASING AREA

▤	Post-Cochrane lacustrine sediments
☐	Marine sediments
▨	Cochrane till
▒	Terminal & recessional moraine
╱	Esker
▥	Esker delta
⊘	Fluting, drumlins, striae
—X—	Late Cochrane Ice Front
•—•—•	Raised beach
.2	Section location with reference
⊙	Interglacial beds of Missinaibi - type
F	Marine fossil location
⊖	Alluvial pyrope garnets of assumed kimberlitic origin

REFERENCES

1 Dyer (1929)
2 Hughes (1956)
3 Hughes (1961)
4 Keele (1920)
5 McLearn (1926)
6 Ontario Hydro (unpublished)
7 Terasmae & Hughes (1960)

Map modified after Boissonneau (1965)

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CHRONOLOGY of the PLEISTOCENE EPOCH

(Prest 1957, p. 444)

STAGE	SUBSTANCE	DURATION	Age in years
WISCONSIN	COCHRANE	100,000 YEARS	7000-8000
	TIMISKAMING INTERVAL		8000-9500
	VALDERS		9500-11,000
	TWO CREEK INTERVAL		11,000-12,000
	CARY		12,000-14,500
	BRADY INTERVAL		14,500-17,000
	TAZEWELL		17,000-18,000
	INTERVAL		18,000-20,000
	IOWAN		20,000-21,000
	INTERVAL		21,000-22,000
	FARMDALE		22,000-25,000
	ICE ACCUMULATION		25,000-45,000
	INTERGLACIAL PERIOD		45,000-60,000
	ICE ACCUMULATION		60,000-100,000
SANGOMAN		125,000	
ILLINOIAN		100,000	
YARMOUTH		200,000	
KANSAN		100,000	
AFTONIAN		300,000	
NEBRASKAN		100,000	

GENERALIZED PLEISTOCENE STRATIGRAPHY IN THE OPERATION KAPUSKASING

NORTH OF THE PINARD MORAINE

Local Name	Thickness feet	General Description
RECENT	4- 6	Muskeg and Bog Deposits
LACUSTRINE AND FLUVIAL SEDIMENTS	2	Fresh water silts and silty gravels.
MARINE SEDIMENTS	5-25	Grey, plastic fossiliferous marine clay.
UPPER TILL	3-20	Light grey to brown, sandy till and reworked interglacial sand and clay.
MISSINAIBI BEDS	4-30	Grey, peaty, silty, interglacial clay; some white sand.
MIDDLE TILL	10-55	Dark grey to black boulder clay, glaciofluvial sand and gravel.
LOWER TILL	10	Dark, rusty brown till

SOUTH OF THE PINARD MORAINE

Local Name	Thickness feet	General Description
RECENT	5-14	Bog Deposits
LACUSTRINE AND FLUVIAL SEDIMENTS	3	Fresh water silts and clays
COCHRANE TILL	5-15	Tan brown, boulder clay, ablation till; bluish grey, clay, basal till.
OUTWASH	up to 50	Fine, yellow clay.
BARLOW-OJIBWAY SEDIMENTS	40-50	Lacustrine, bedded silts and varved clays.
MATHESON TILL	40	Boulder clay, substratified drift, gravel, silt, and sand. Pinard Moraine - fine sand.

FIGURE 8 Summary of principal data relating to the Pleistocene succession in the OPERATION KAPUSKASING AREA

associated glaciofluvial deposits called the Matheson Till by Hughes (see Boissonneau, 1966, p. 568). The till is overlain by Barlow-Ojibway deposits consisting of varved clay and silt. In most of the southern part of the area these lacustrine deposits are overlain by the Cochrane Till sheet. Directly south of the Pinard Moraine, however, a unit of fine silt and sand lies between the Barlow-Ojibway and Cochrane deposits. Fresh water lacustrine and fluvial sediments overlie the Cochrane Till in some localities.

Recent bog and river deposits mantle all of the Pleistocene sediments in the area.

Figure 9, illustrates the relationship between the northern and southern stratigraphic units and presents a north-south section through the Pleistocene deposits of the area.

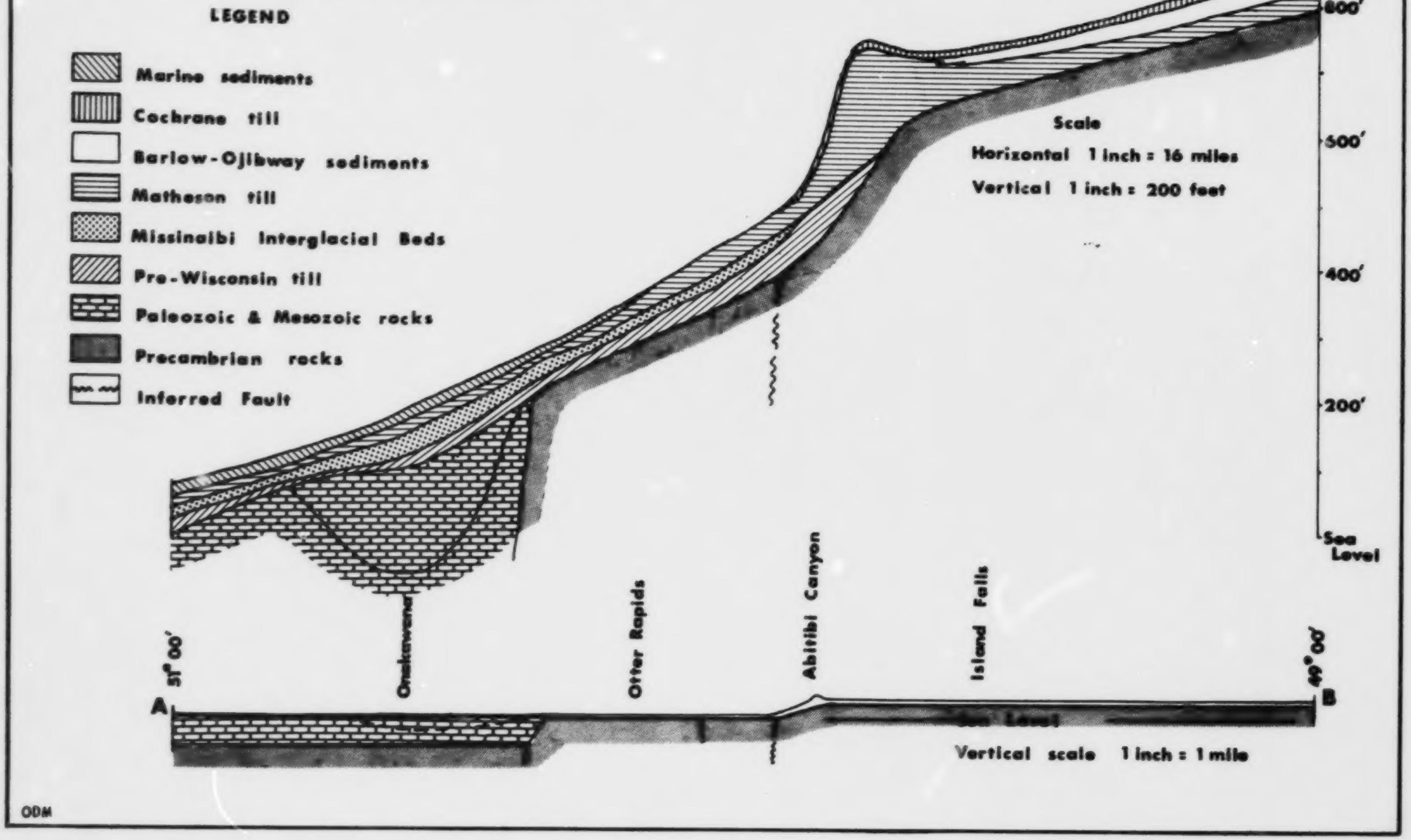
Pleistocene History

In the light of the age of the Missinaibi Beds, the Lower and Middle Till sheets represent early Wisconsin and older glaciations. As only two till sheets, have been identified, it would indicate that the interglacial stages (Sangamon, Yarmouth, and Aftonian) are not represented and that the area was covered by glaciers throughout most of pre-Wisconsin Pleistocene time. Following the retreat of this ice sheet, the Missinaibi Beds were deposited during early Wisconsin time. Palynological studies (Terasmae and Hughes, 1960) indicate that the climate at that time was much like the present climate in the same area.

FIGURE 9

PLEISTOCENE STRATIGRAPHY

Section A - B (See Figure 7)


LEGEND
Marine sediments
Cochrane till
Barlow-Ojibway sediments
Matheson till
Missinaibi Interglacial Beds
Pre-Wisconsin till
Paleozoic & Mesozoic rocks
Precambrian rocks
Inferred Fault
Scale
Horizontal 1 inch = 16 miles
Vertical 1 inch = 200 feet
800'
500'
400'
200'
Sea Level
A
51° 00'
Onakawana
Otter Rapids
Abitibi Canyon
Island Falls
49° 00'
B
Sea Level
Vertical scale 1 inch = 1 mile
ODM

The area was again covered by glaciers during the advance of the Farmdale sub-stage and remained covered throughout most of Wisconsin time until the ice sheet retreated to the area of the Pinard Moraine during the Timiskaming interval. Eskers of the same age as these glacial deposits trend north and indicate a general north to south movement for the ice sheet. These eskers have been modified by wave erosion during the formation of Lake Barlow-Ojibway and by overriding during the Cochrane readvance.

Numerous esker deltas, south of the Pinard Moraine probably represent sites of short term pauses in the retreat of the ice sheet. During this period, Lake Barlow-Ojibway formed between the ice front and the height of land to the south of the area, and the Pinard Moraine was built up as a major recessional moraine. The Barlow-Ojibway sediments were deposited at this time and it is the authors' belief that the fine silt and clay units which overlie the Barlow-Ojibway sediments immediately to the south of the Pinard Moraine and which overlie the Pre-Wisconsin Middle Till immediately to the north of the Pinard Moraine represent outwash deposits formed around the Pinard Moraine. The Cochrane readvance took place in at least two phases in the area. South of Hearst, in the northeast corner of Lowther township two directions of glacial striae occur, one trending southeast, the other trending southwest. The southeasterly trending striae appear to be older. In Area A (Figure 7) fluting in the Cochrane Till indicates an early southeasterly readvance of the glacier. Boissonneau (1966) believes that this area was protected from being over ridden by the later southwesterly readvance by an ice block which remained after the earlier southeasterly advance had wasted away. Fluting is well preserved in much of the area affected by the Cochrane readvance. Much of the Cochrane Till is simply reworked sediments originally deposited during Barlow-Ojibway and earlier sub-stages. Following the retreat of the Cochrane glacier, marine transgression occurred in the north part of the area. The southern limit of this marine transgression is indicated in Figure 7. South and east of the Pinard Moraine fresh water lacustrine deposits overlie the Cochrane Till in many places. The lakes in which these sediments were deposited were probably short-lived. Recent organic soil, bog, and muskeg deposits mantle the Pleistocene deposits throughout the area. Dyck et al (1966) have radio-carbon dated wood at the top of the Barlow-Ojibway deposits at 7660± 140 years. These sediments are overlain by one foot of lake sediments that have been interpreted as having formed in a residual pond following the drainage of Lake Barlow-Ojibway. Eight feet of peat overlies the lake sediments and basal layers of the peat have been age-dated at 7150± 140 years. These age determinations were made on material from the Chin Lake area, approximately 30 miles north of Iroquois Falls, Ontario.

Apparently a major factor in the Pleistocene history of the area was the bedrock topography. Limited information from diamond drilling indicates that the bedrock slopes towards James Bay on the average at 3 to 5 feet per mile. In plotting Pleistocene and Paleozoic sections across the area it becomes obvious that there are definite breaks in this gently sloping plain and that the breaks correspond in general with changes in thickness of the Paleozoic rocks or changes in character of the Pleistocene stratigraphy (See Figure 9). It is suggested that a scarp or at least a fairly abrupt change in elevation of the bedrock surface exists in the Abitibi Canyon area and that it: (1) protected the Missinaibi Beds and pre-Wisconsin tills from erosion during the Wisconsin glaciation. This hypothesis is supported by the fact that these units were apparently scoured away on the higher level of the bedrock surface south of Abitibi Canyon. (2) May have caused the halt in the retreat of the glacier during the Timiskaming interval as it would result in a thickening of the ice which could stabilize the retreat. Correlation in location between the Pinard Moraine and the change in elevation of the Precambrian basement would suggest more than a coincidental relationship.

This interpretation of the Pleistocene history of the area would indicate that serious problems will be encountered in any geochemical work undertaken in the area. To the north of the Pinard Moraine, the upper soils are marine sediments or Matheson till both of which represent reworked sedimentary material whose geographic relationship to the bedrock is very uncertain. To the south of the Pinard Moraine, similar conditions prevail, the upper soils being either lacustrine Barlow-Ojibway sediments or reworked sediments of a mixed origin (i.e. mixed Barlow-Ojibway sediments and Matheson till from north of the Pinard Moraine).

Also, much of the lacustrine sediment consists of apparently impervious clay. This would have a serious effect on the migration from weathered bedrock of mobile elements in groundwaters.

It would seem that the best sites for geochemical sampling would be along the major rivers where erosion reaches or approaches bedrock so that the samples would be obtained from a point near the base of the lowest till layer in any particular area.

STRUCTURAL GEOLOGY

Introduction

A distinct anomaly in regional structure occurs within the map-area. Structural trends within the granulite zone (Figure 2) trend northeast, parallel to the long axis of the structure and cut obliquely across the regional structural trends in the volcanic-sedimentary, and gneiss complexes. There is also an anomaly in the regional structural trends to the east and west of the granulite zone.

To the east of the granulite zone fold axes trend west to northwest, and the dominant strike trend of diabase dikes is northerly with a few northeasterly trends in the southeast corner of the area.

To the west of the granulite zone, fold axes trend north-northeast to east-northeast, and two sets of diabase dikes occur striking northwest and northeast respectively.

Folding

The folding within the area is undoubtedly complex, certain volcanic-sedimentary belts have probably been deformed a number of times, and the amount of useable structural data obtained during the present survey was minimal.

The Kabika River Complex (Figure 2, Location A) has an overall anticlinal structure plunging northwest with two granitic stocks emplaced into the central part of the structure. This interpretation is supported by top determinations. Structural trends within the Sangster Lake Gneiss Belt (Figure 2, Location B) conform with the trend of the Kabika River structure and it is interpreted as a more highly metamorphosed segment of the Kabika River volcanic-sedimentary complex.

The synclinal form suggested for the Detour Lake Complex (Figure 2, Location C) is conjectural; however, mapping by the Quebec Department of Natural Resources indicates that this synclinal structure is present (Remick, personal communication).

The limited information available suggests that within the map-area the volcanic and sedimentary rocks of the Cochrane Complex (Figure 2, Location E) have a monoclinal, steeply south-dipping, south-facing structure.

The Partridge River Complex (Figure 2, Location D) has an inferred synclinal structure with an east to east-northeast trending axis. Faulting complicates the structural picture.

To the west of the granulite complex fold axes trend in a north-northeast to east-northeast direction. The few outcrops of mafic metavolcanics of the Pivabiska Complex (Figure 2, Location H) display east-northeast-striking foliation.

Strike trends within the Opasatika Complex (Figure 2, Location G) are east-northeast. The rocks are tightly folded but too few top determinations were available to permit a valid structural interpretation.

The Saganash Complex (Figure 2, Location F), consisting of amphibolite, meta-iron formation, and metasediments, trends in an northeasterly to north-northeasterly direction as do the gneissic rocks immediately adjacent to the east and west. It should be noted that the Saganash Complex lies directly southwesterly along strike from the granulite complex and displays a similar anomalous structural trend.

Because of the poor rock exposure and the overall similarity of the rock types within the gneiss complex, it is not possible to trace regional structures. Variations in attitudes within the gneisses suggest complex folding.

Faulting

Faulting in the area occurs along two main strike trends; north to northwest and northeast respectively.

The north- to northwest-striking set displays both right- and left-hand horizontal displacement and in many cases the vertical displacement must be considerable. The age of faulting is uncertain and it is highly probable that the faulting occurred over an extended period of time. Some of the faulting may be pre-granite whereas other faults of this trend offset the northeast-trending diabase dikes which are believed to be of late Proterozoic age (approximately 1200 million years).

The northeast-striking set of faults has only been identified within and to the west of the granulite zone. The western limit of major northeast-striking faults is along the east side of the Opasatika Complex. The granulite zone proper represents a complex horst structure composed of numerous fault slices. The dominant movement has been in a vertical sense with the central horst, that is, the granulite zone, having the greatest vertical uplift, the east block the least relative uplift, and the west block an intermediate amount of uplift. This is supported by the metamorphic grades identified within the fault blocks. The rocks within the central horst are all in the high grade Pyroxene Granulite facies of metamorphism. To the west of the horst block the rocks are metamorphosed to the Upper Almandine Amphibolite facies, locally to the Pyroxene Granulite facies although they always retain gneissic textures with generally east-west strikes. Immediately to the east of the horst block occur metavolcanic, metasedimentary, and gneissic rocks of Epidote Amphibolite to Almandine Amphibolite metamorphic facies.

A minimum age of approximately 1200 million years is suggested for the age of this faulting as the northeast-trending dikes are offset by these faults. Two ages of carbonatite, the oldest being early Proterozoic, are spatially related to the northeast-striking fault zones and may indicate a maximum age of over 1700 million years for the faulting.

As mentioned previously, there is evidence for a fault scarp along the Precambrian - Paleozoic contact in the west part of the area. The fault at the foot of Long Rapids on the Mattagami River in Kipling township is older than the northeast-striking faults. No evidence for faulting was found along the Precambrian - Paleozoic contact to the east of the granulite zone; however, it is of interest to note that the trend of the contact is similar to the east and to the west of the granulite zone. Also, the area of offset lies between the limits of the major development of the northeast-striking faults. This could be interpreted as indicating on a regional scale that there has been right-hand lateral offset along the northeast-trending zone.

REGIONAL GEOPHYSICAL DATA

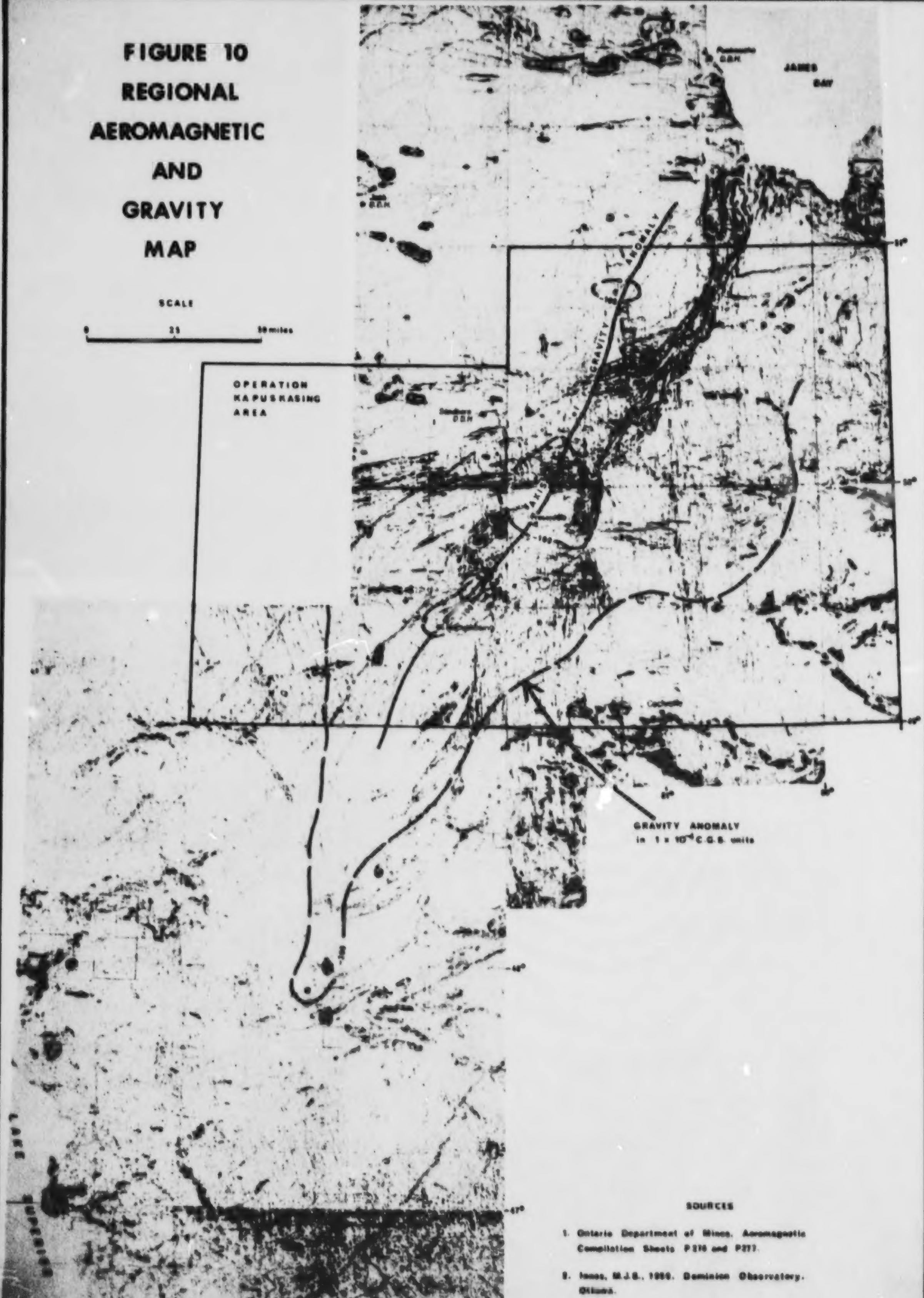
Aeromagnetic and gravity maps have been published that cover most of the Operation Kapuskasing area. There is a very close correlation between geologic and aeromagnetic data (P. 420 in press). Because of the paucity of outcrop, the aeromagnetic maps were relied upon heavily in interpreting the geology of the area.

The most striking feature on the aeromagnetic map (Figure 10) is the northeast-trending anomaly that runs from James Bay to Fraserdale where it dies out abruptly and then resumes again south of Kapuskasing and can be traced approximately 100 miles further to the southwest where it gradually dies out. This anomalous zone divides the area into two parts each of which has distinctive structural trends that have already been discussed.

The regional gravity map published by the Dominion Observatory (Innes 1960) also outlines a broad, northeast-trending anomalous gravity high as indicated in Figure 10. The axis of this gravity high is parallel to but 20 to 25 miles west of the aeromagnetic high. This gravity anomaly like the aeromagnetic anomaly dies out to the southwest.

Wilson and Brisbin (1965) have interpreted the gravity anomaly as indicating a pronounced upwarp in the Conrad Discontinuity, the seismic discontinuity inferred to mark the contact between the granitic and the basaltic crystal layers. The crust is thinnest along the axis of the gravity anomaly, thickening to the east and west. The present mapping indicates that there is a close correlation between the gravity anomaly and the zone of northeast-faulting and confirms the interpretation of a definite upwarping of the earth's crust along the zone as indicated by the metamorphic grade.

It is of interest to speculate on the period of time during which this zone had an influence on regional tectonics. As indicated above there is a striking change in structural



SCALE
0
25
50 miles
OPERATION
KAPUSKASING
AREA
JAMES
BAY
GRAVITY ANOMALY
GRAVITY ANOMALY
in 1 x 10⁻⁴ C.G.S. units
LAKE SUPERIOR
ODM

FIGURE 10
REGIONAL
AEROMAGNETIC
AND
GRAVITY
MAP

SOURCES

1. Ontario Department of Mines, Aeromagnetic Compilation Sheets P216 and P217.

2. Innes, M.J.S., 1959. Dominion Observatory, Ottawa.

trends across the anomalous zone. This could be interpreted in two ways. Either the zone has been structurally active throughout the geologic history of the area and somehow influenced the regional structural patterns or the change in structural trends was caused by a rotation of the continental blocks on either side of the zone during Proterozoic time when faulting was definitely active in the area.

On the basis of present ideas regarding the Archean age of deformation of the volcanic-sedimentary complexes it could be inferred that the zone was structurally significant in Archean time as the Sagansh Volcanic Complex that lies within the anomalous zone has been folded about northeasterly-trending axes. The possibility of refolding of the Saganash Complex during Proterozoic time cannot be ruled out however.

On the other hand, in spite of the differences in structural trends to the east and west of the granulite zone, there is a strikingly similar geometrical relationship between the structural units within each block. The relative angles between the fold axes, and the north-striking and northeast-striking dikes east of the granulite zone are very similar to the angular relationships between the fold axes and dike trends west of the granulite zone (see Figure 2). Such a structure could be formed if the northern section of the anomalous zone is taken as a wedge-shaped horst block which has been faulted into place with a rotational movement about an east-trending, horizontal axis of rotation. The aeromagnetic data supports the hypothesis that the granulite zone widens to the north under the Paleozoic sedimentary rock cover.

The aforementioned hypotheses are all untested but could be studied by:

(a) age determinations on diabase dikes within the map-area.

(b) paleomagnetic studies on diabase dikes of the same age to test the hypothesis of rotation by a fault wedge.

(c) more detailed structural studies of the anomalous zone along its whole length.

(d) detailed metamorphic studies.

ECONOMIC GEOLOGY

A variety of mineral occurrences are known to be present in the area. The Paleozoic and Mesozoic sedimentary rocks of the James Bay Lowlands contain deposits of fireclay, kaolin, quartz sand, lignite, gypsum, and iron. Recent data indicates the presence of post-Middle Devonian kimberlite dikes and sills and related lamprophyre dikes cutting the Paleozoic strata.

In the Precambrian, south of the James Bay Lowland, mineral occurrences containing iron, niobium (columbium), thorium, uranium, gold and lithium, and prospects with small amounts of copper, nickel, zinc, and molybdenum sulphides have been reported.

The earliest mineral exploration in the area was centred on the industrial mineral and fuel possibilities of the Paleozoic and younger rocks. Unrecorded prospecting may have been undertaken but it would seem that interest in exploration in the area has been sporadic until recent years. The publication of the government aeromagnetic maps in 1964 attracted considerable attention to the area. Six exploratory licenses were issued by the Ontario Department of Mines to companies interested in the investigation of the Fraserdale - James Bay anomaly. This led to the discovery of a large columbium deposit on which development work is still being done. No mines have been brought into production in the area.

Considerable staking activity has been reported in the Burntbush River area during the fall of 1966 and winter of 1966-1967. Little information is available to explain the interest in the area but it is known that some development work, including drilling, is being done.

BASE METAL AND RELATED SULPHIDES

In 1965, base metal sulphide intersections of unknown grade or quantity were drilled in Hurdman township. The host rocks are probably gneisses; however, outcrop is sparse in the area and the possibility of metavolcanic, metasedimentary or even mafic intrusive rocks cannot be eliminated. The pattern of drilling, as indicated by old drill sites seen in the area, does not appear to be following regional trends within the gneiss complex.

Disseminated chalcopyrite has been reported in an outcrop of gabbro in the northwest corner of Owen township, approximately ten miles west of Kapuskasing.

The Cargill carbonatite complex, discussed below, contains disseminated chalcopyrite as does a carbonate vein in Pitt township southeast of Coral Rapids.

Many diamond drill records indicate that pyrite and pyrrhotite have commonly been found in the area, mainly within the volcanic-sedimentary rock complexes but also within the gneiss complex.

Within the volcanic-sedimentary complexes there appears to be a close spatial association of the pyrite-pyrrhotite mineralization with zones of iron formation and with zones of major change in the lithologic character of the rock, namely from mafic volcanic to felsic volcanic, or sedimentary rock types. Limited geophysical data indicates that these sulphide zones are probably stratiform at least on a gross scale.

Heavily mineralized pyrite-pyrrhotite bearing outcrops have been mapped on the south shore of Sangster Lake in Sangster township; near Fergus Lake in Fergus township; and in central Caithness township. The Caithness and Fergus township occurrences are in sulphide-bearing iron formation. Similar occurrences have been found in the same general area in Shearer and Parnell townships. The Sangster Lake occurrence is in an amphibolite zone within the Sangster Lake Gneiss Belt. This may be a meta-iron formation as well since the rocks are probably metamorphic equivalents of the Kabika River Complex which contains considerable amounts of iron formation. Analyses of samples from all of these occurrences show only trace amounts of copper, zinc, and nickel.

NICKEL

Only one occurrence of nickel within the map-area is known to the authors. On the North French River, millerite (NiS), finely disseminated in pyroxenite, has been reported by the Geological Survey of Canada (Gaucher 1966, p. 190). X-ray methods confirmed the identification of millerite. No significant nickel assays were obtainable from samples of the pyroxenite taken during the present survey.

GOLD

Gold was discovered in the southeast part of McCowan township before 1940. Quartz veins, sparsely mineralized with chalcopyrite, arsenopyrite and galena occur in silicified and locally pyritized metagreywacke. Quartz porphyry intrusions were also reprted in the general vicinity of the veins. The most recent work was carried out in 1948.

No other gold occurrences have been reported and during the present survey no vein-type mineralization of any apparent significance was observed.

IRON

Iron formation is common in the Precambrian of the area and has been evaluated in at least three areas as potential iron ore.

In Kenning township the Triana Explorations Company in 1957 outlined a magnetite-bearing iron formation having a strike length of 2,400 feet and an average width of 200 feet. Aeromagnetic data has been interpreted as indicating a large Z-shaped fold with the enriched iron formation at the nose of the fold. The average grab sample grade is 24.5 percent iron and a possible tonnage estimate is 40,000 tons per vertical foot. Regularly banded magnetite separated by layers of quartz, mica, and amphibole (hornblende: grunerite = 1:5) comprise the iron formation. The magnetite is fine-grained and constitutes from 20 to 50 percent of the rock.

Beneficiation tests indicate that samples averaging approximately 40 percent iron could be concentrated to between 65.5 and 66.7 percent iron with 6.6 to 8.6 percent silica. Ratio of concentration was 2.5 to 1.

Conwest Exploration Company Limited has drilled similar magnetite-bearing iron formation in Newman and Bradette townships.

Iron formation occurs in amphibolitized mafic metavolcanics in Fenton and Slack townships south of Kapuskasing. Magnetometer surveys indicate that the bands of iron formation are quite widespread and some are continuous for four to five miles along strike. The iron formation consists of bands of granular quartz and magnetite with minor amounts of black, cherty quartz. Diamond drilling by Camflo Mattagami Mines Limited intersected the following values in lot 2, concession 5, Fenton township (Table 2).

Table 2 FENTON TOWNSHIP IRON FORMATION
(from assessment work submitted by Camflo Mattagami Mines, Limited)

DDH Number	Footage	Width	Assay Value % Iron
No. 1	309.5-379.0	69.5	22.30
45° to N.W.	543.0-597.0	54.0	20.34
No. 2	100.0-175.0	75.0	25.69
45° to N.W.	210.0-225.0	15.0	23.17
	255.0-300.0	45.0	25.44
	317.0-335.0	18.0	19.00

A sideritic iron deposit occurs in the Devonian Abitibi River Formation in Hogg township at Grand Rapids on the Mattagami River (Figure 11). The deposit was discovered by Dr. R. Bell of the Geological Survey of Canada in 1875. The deposit has been described by Baker (1911), Cross (1920), and Dyer (1928).

The mineralization occurs in solution cavities, enlarged joint planes, and fractures in the fossiliferous limestone of the Abitibi River Formation. The solution cavities formed during a Devonian-Cretaceous erosional interval.

The deposit consists essentially of dark brown to white, compact to granular siderite. Limonite and minor hematite occur as vuggy to nodular masses and as outer layers on the sideritic material. The limonite occurs in a distinct zone overlying the siderite (see Figure 12) and is an oxidation product of the original sideritic material. Texture varies within the deposit. Finely laminated to massive siderite of unusually high grade occurs near the bottom of the deposit whereas towards the top of the siderite zone interbeds of well sorted, clear, quartz sand occur. The limonite zone is commonly conglomeratic with oxidized boulders of siderite in a dark brown to black, sandy, limonitic matrix.

The sideritic deposit formed by the reaction of limestone with iron-rich, sulphate-bearing ground waters and its formation probably involved both the direct precipitation of siderite and the replacement of existing limestone. Evidence for replacement is found in the occurrence of sideritic fossils as rounded, waterworn cobbles.

The presence of boulders of siderite containing fragments of Cretaceous lignite and the layers in the siderite of pure quartz sand, also probably of Cretaceous age, indicate that the iron deposit formaed during Cretaceous time.

The locations of the iron showings are indicated in Figure 11. Cross (1920) differentiated good ore as that consisting of high grade siderite, and sandy ore as that containing a considerable amount of silica, clay, limestone, and organic matter. The approximate exposed dimensions of the showings are given in Table 3.

FIGURE 11 - GRAND RAPIDS IRON DEPOSIT

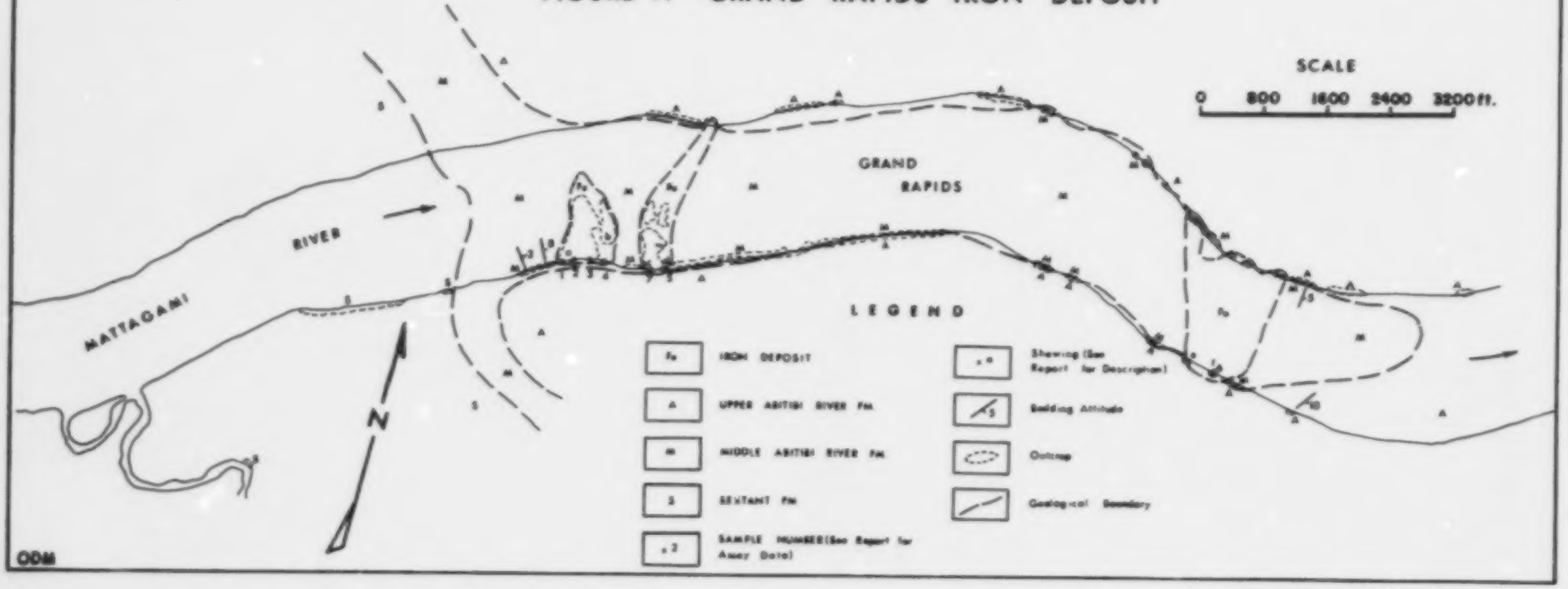

SCALE
0
800
1600
2400
3200 ft.
GRAND RAPIDS
MATTAGAMI
RIVER
N
LEGEND
Fe IRON DEPOSIT
A UPPER ABITIBI RIVER Fm
M MIDDLE ABITIBI RIVER Fm
S SEXTANT Fm
SAMPLE NUMBER (See Report for Assay Data)
Showing (See Report for Description)
Bedding Attitude
Outcrop
Geological Boundary
ODM

Table 3 | DIMENSIONS OF THE GRAND RAPIDS IRON SHOWINGS

Location	Showing (see Fig. 11)	Material	Width along river	Thickness
West end of Rapids	a	Siderite	600 ft.	15 ft.
	b	Limonite	30	10
East end of Rapids	c	Limonite	25	20
	d	Limonite	20	15
	e	Limonite	50	10
	f	Limonite	35	10

As the showings pass under heavy drift along the banks of the river and are partly water covered in the river bed, the exact dimensions of the deposit are unknown. It is not known whether other solution cavities are present in the area.

Data in Table 4 gives an indication of the grade of the various types of material.

Table 4 | ANALYTICAL DATA FOR GRAND RAPIDS SAMPLES

Type of Material	Sample[2] No.	Length Sampled	Fe	SiO_2	S	P	Mn	TiO_2	Loss
High grade[1] Siderite	1	150 ft.	45.78	0.20	.430	.090	.96	.70	30.60
	2	180	45.57	0.44	.380	.100	.78	.70	30.20
	3	60	44.73	1.84	.322	.032	.87	.70	30.60
	4	160	43.47	3.32	.416	.023	1.60	.65	29.60
Limonite[1]	5	30	57.12	3.64	.084	.072	1.94	.73	12.86
	6	120	43.05	17.78	.048	.095	1.10	.83	13.40
	7	800-1000	39.31	27.00	—	—	—	—	—
Sandy[3] Ore	—	10	30.32	42.46	—	—	—	—	—
	—	12	35.37	29.10	—	—	—	—	—
	—	15	38.40	29.18	—	—	—	—	—

1. Algoma Steel Corporation, unpublished data.
2. See Figure 11 for sample locations.
3. Cross, 1920.

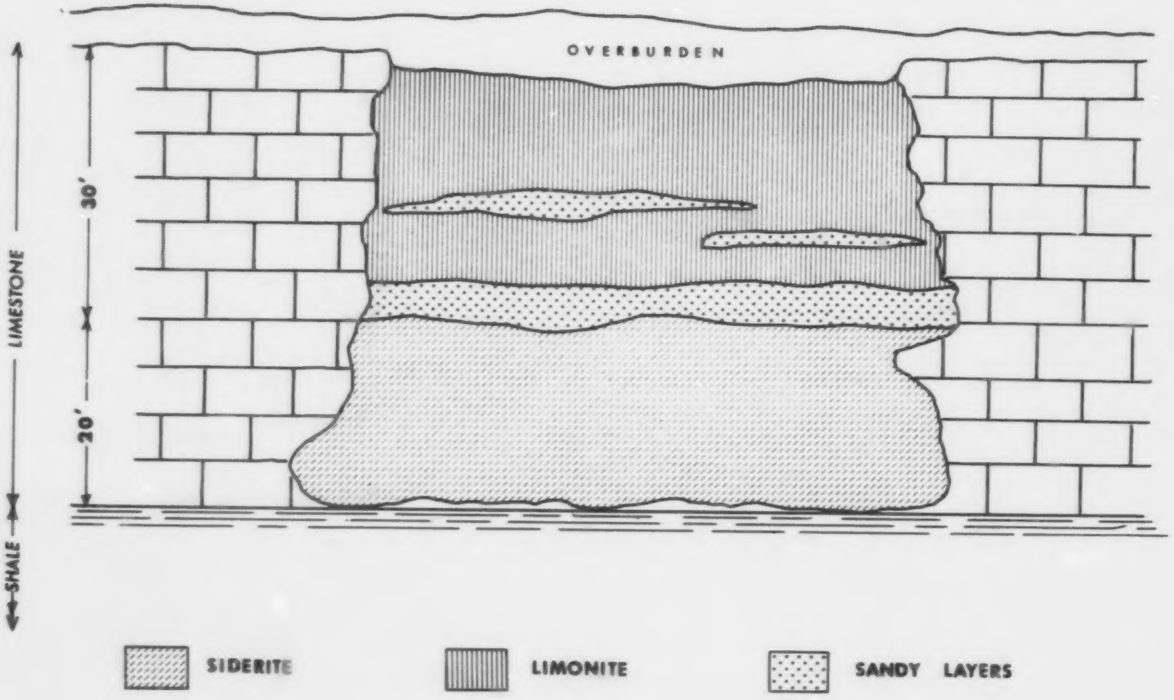
The following appraisal of the deposit was made by the Algoma Steel Corporation in 1956.

"The showings at the head of the rapids do not appear to be of commercial value because they are too thin (maximum thickness 25 feet) and contain considerable intermixed sandy material. The deposits at the foot of the rapids are more promising because only the limonite capping is exposed and an unknown thickness of siderite may reasonably be expected to underlie it.

Solution cavities occur in abundance at certain erosional surfaces in many regions of the world. The cavities characteristically develop along joint planes in flat-lying limestone; they tend to be long and narrow in dimension. Deposits of siderite and limonite within limestone are found in Austria and Spain (Bilbao). The Tri-State region of central U.S. is an example in which a heterogeneous system of solution cavities is mineralized with lead and zinc. In general, solution cavities tend to occur in groups; therefore, where one has been located, other occurrences may reasonably be expected nearby.

FIGURE 12

DIAGRAMMATIC SKETCH OF SIDERITE–LIMONITE OCCURRENCE IN A SOLUTION CAVITY IN LIMESTONE


OVERBURDEN
LIMESTONE
SHALE
30'
20'
SIDERITE
LIMONITE
SANDY LAYERS

ODM

In application to the Grand Rapids area, with two iro-filled cavities located, other cavities may be expected to occur beneath the drift in the vicinity of the Rapids and the James Bay lowland in general. The depth of any such cavities would be limited by the thickness of the limestone member in which they formed."

An outcrop of ferruginous limestone was described by J. M. Bell (1904) on the Opasatika river in Bradley township. this occurrence was not located during the present survey but may have been either under water or covered with overburden.

LITHIUM

Lithium-bearing granitic pegmatites have been reported from two localities in the area. A complex zoned pegmatite occurs cutting the granitic rocks in southeast Steel township, approximately 50 miles east of Cochrane (Lumbers 1962, p. 29, 30, 45). The pegmatite consists dominantly of quartz and orthoclase with minor amounts of spodumene, columbite-tantalite, muscovite, tourmaline, and rare molybdenite.

A spodumene-bearing pegmatite has been reported (Ferguson 1955) in lot 7, concession IV, Lowther township, south of Hearst, but was not located during the present survey. The pegmatite is reported to occur in a large outcrop of pink granite. Quartz and feldspar are the dominant constituents with some muscovite, spodumene, and lepidolite.

MOLYBDENUM

Molybdenite has been reported in granitic pegmatites and quartz veins in the volcanic-sedimentary complex in Steel township (Lumbers 1962, p. 29, 45). The veins and dikes range in width from one inch to one hundred feet. A pegmatite dike, north of Cochrane in Blount township on the Abitibi River, cuts the gneiss complex and contains muscovite and traces of molybdenite.

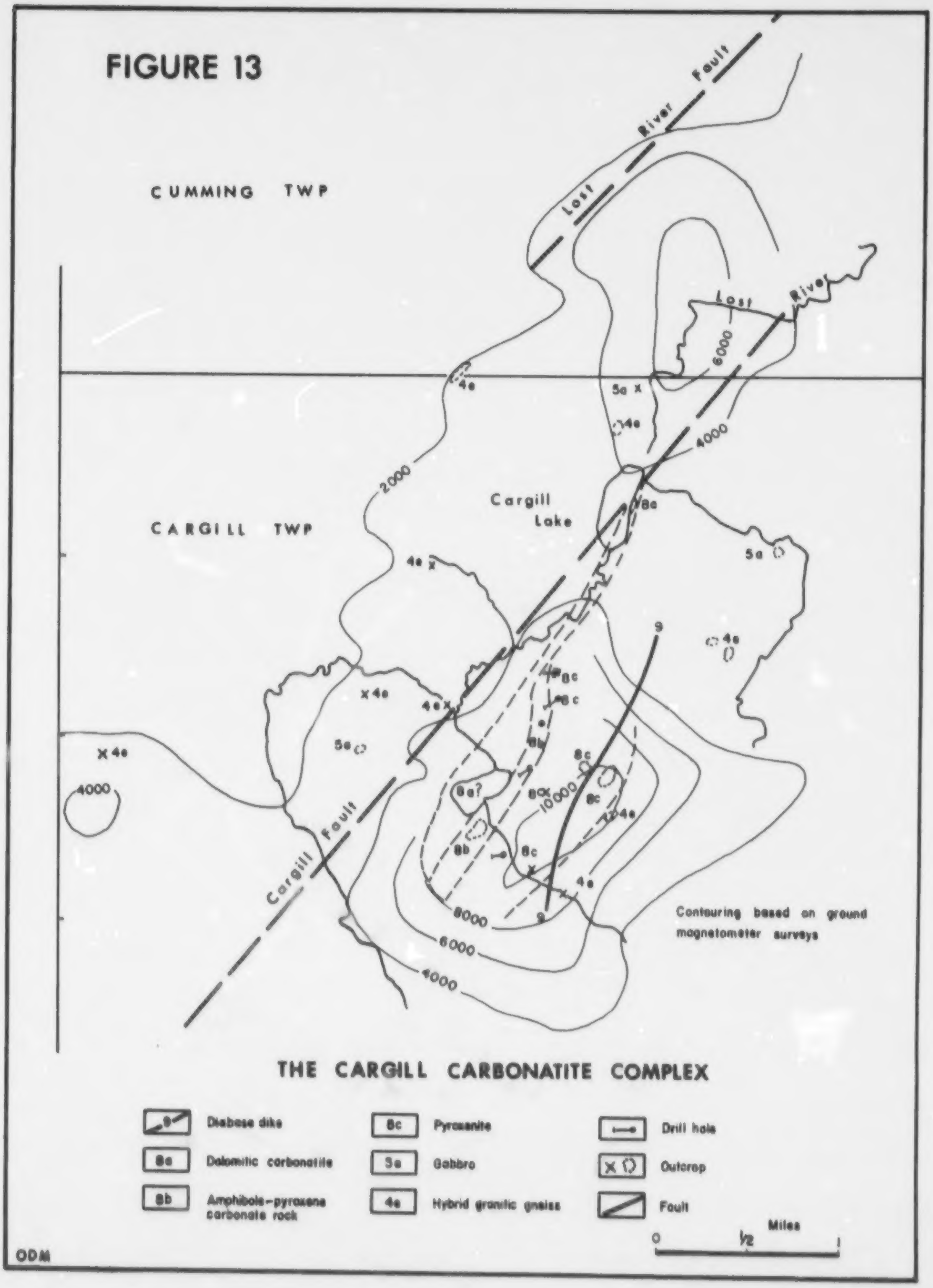
CARBONATITE

Carbonatite intrusions occur in at least four places within the map-area, two in the gneiss complex in Cargill township and in the Clay-Howells township area, and two within the granulite zone on the Consolidated Morrison exploratory license area. The Cargill Complex pyroxenite contains disseminated magnetite and chalcopyrite, the Clay-Howells Complex contains disseminated to massive magnetite, and one of the Consolidated Morrison bodies contains disseminated pyrochlore in a calcite (sovite) matrix.

The geology of the Cargill Carbonatite Complex is illustrated in Figure 13. The area containing the central part of the complex was staked in 1956 by Continental Copper Mines Limited. Kennco Exploration (Canada) Limited optioned the property and did a geological reconnaissance of the area. Their evaluation of the property was unfavourable.

Four main rock types occur in the carbonatite complex but their extent and the structural relationships between them are very tentative. Medium- to very coarse-grained pyroxenite consisting of titaniferous augite, up to 10 percent olivine, up to 25 percent magnetite and traces of pyrite, pyrrhotite and chalcopyrite are cut by very coarse white calcite

FIGURE 13


CUMMING TWP
CARGILL TWP
Lost River Fault
Lost River
Cargill Lake
Cargill Fault
2000
4000
6000
8000
10000
4e
5a
8a
8a?
8b
8c
9
Contouring based on ground magnetometer surveys
9 Diabase dike
8a Dolomitic carbonatite
8b Amphibole-pyroxene carbonate rock
8c Pyroxenite
5a Gabbro
4e Hybrid granitic gneiss
Drill hole
Outcrop
Fault
0
½
1
Miles
ODM

THE CARGILL CARBONATITE COMPLEX

veins containing up to 20 percent apatite. A second type of carbonate rock outcrops on the shore of Cargill Lake. It is a very fine-grained buff coloured, dolomitic carbonate. Hybrid carbonate-biotite-pyroxene-hornblende rocks occur apparently as a transition zone between massive carbonatite and pyroxenite.

Quartz gabbro bodies containing augite and hypersthene occur in the immediate area but are not considered to have any genetic relationship to the carbonatite intrusion. The host rocks for the complex are hybrid granitic gneisses of the Migmatite Complex. The carbonatite complex is cut by a north-northeast trending diabase dike.

No rare-earth minerals have been identified in the carbonatite complex and assay values were low (Nb - 50 ppm, La - 200 ppm, Ce - 1000 ppm).

The Clay-Howells Carbonatite Complex was originally located during an aeromagnetic survey by Lundberg Exploration in the summer of 1954. The aeromagnetic anomaly comprises two highs having the shape of a northeast-oriented dumbell. Approximately 2,000 feet of drilling was done on the Howells township anomaly by a grubstake syndicate of Lundberg Exploration employees. In 1955 the property was optioned by the Steel Company of Canada. Work in the summer of 1955 by C. C. Huston and Associates for the optionee was concentrated on the Clay township anomaly. A ground magnetometer survey was undertaken to detail the aeromagnetic anomaly. Two subparallel, slightly arcuate in plan, northeast-striking anomalies were outlined

(See Figure 14). The northernmost of the two anomalies is the strongest, being 45,000 gammas above local background, with dimensions 3,500 feet long, and 300 feet wide. The geology and structure were outlined by 7,500 feet of drilling.

The carbonatite complex occurs in a roughly circular stock of aegirine syenite approximately eight miles in diameter. The syenite intrudes the gneiss complex and is believed to be of Late Proterozoic age.

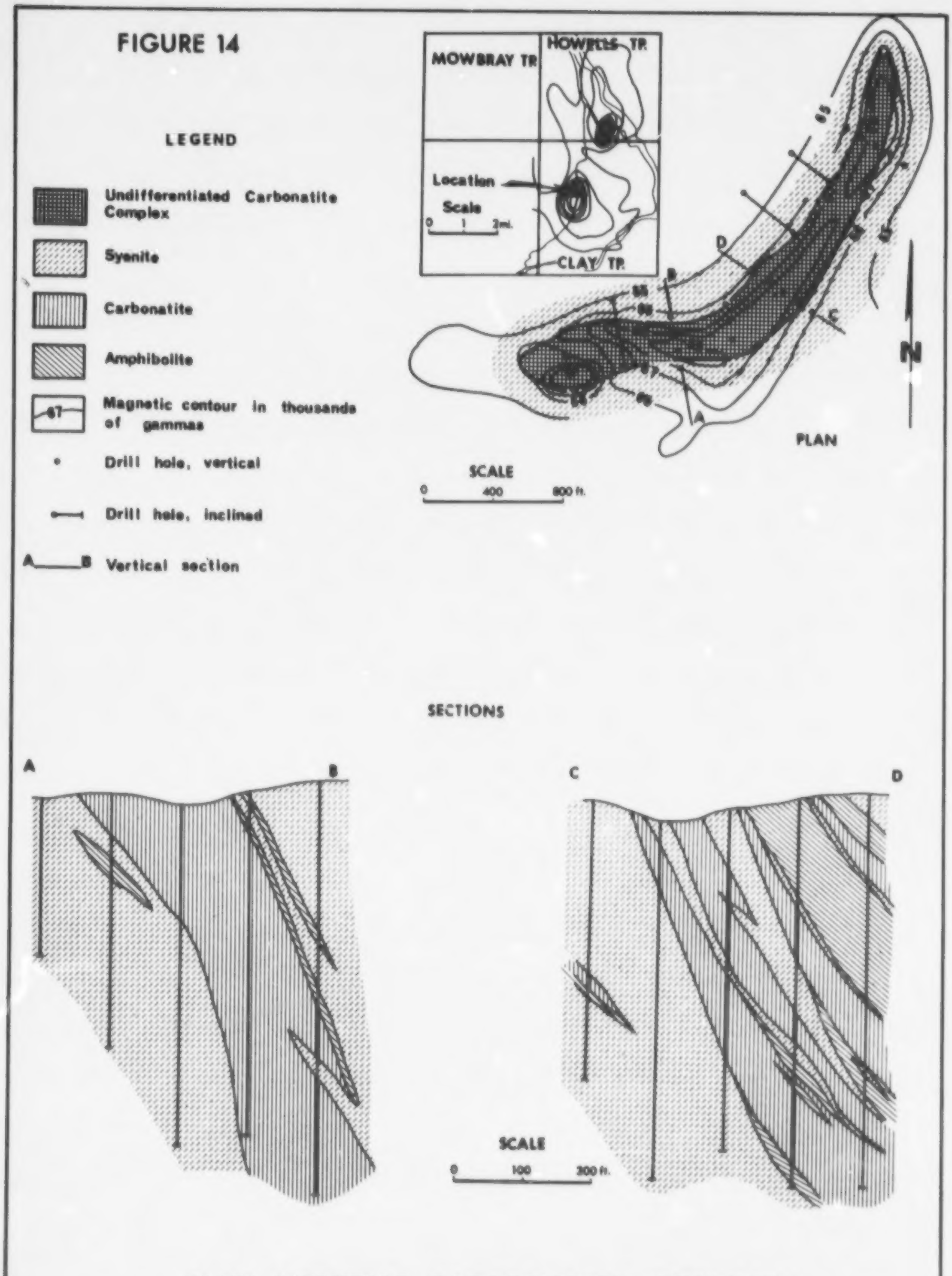
Amphibolitic, garnetiferous carbonate with disseminated magnetite (10 to 80 percent) forms the central part of the carbonatite. Zones of amphibolite occur along the contact between the carbonatite and the syenite host rocks. Figure 14 illustrates the interpreted form of the carbonatite complex.

Milling tests on a small sample of magnetically concentrated ore assayed 70 percent iron, less that 2 percent silica, less than 2 percent manganese, 1.25 percent aluminum, and approximately 0.06 percent sulphur.

Another anomaly strikes northeast through central Hopkins township approximately six miles west of the Clay township carbonatite occurrence. Drilling indicated a mass of biotite gabbro consisting of medium- to coarse-grained plagioclase (An 40-55), augite, brown biotite, and 2 to 3 percent magnetite.

The genetic relationship between the aegirine syenite, carbonatite, and gabbro is not known.

FIGURE 14


LEGEND
Undifferentiated Carbonatite Complex
Syenite
Carbonatite
Amphibolite
67
Magnetic contour in thousands of gammas
Drill hole, vertical
Drill hole, inclined
A B
Vertical section
MOWBRAY TP.
HOWELLS TP.
Location
Scale
0 1 2mi.
CLAY TP.
65
D
B
C
A
N
PLAN
SCALE
0 400 800 ft.
SECTIONS
A
B
C
D
SCALE
0 100 200 ft.

CLAY–HOWELLS CARBONATITE COMPLEX

ODM

DATA FROM ASSESSMENT FILES

Columbium (Niobium)

Consolidated Morrison Exploration Limited has discovered within their exploratory license area (lying within the granulite zone between latitudes 50°35'N and 50°54'N) a carbonatite body that contains disseminated pyrochlore ($NaCaNb_2O_6F$). A second apparently barren carbonatite body was discovered on the Goldray (a company associated with Consolidated Morrison) exploratory license area that lies within the granulite zone between latitudes 50°13' and 50°30'N. Extensive diamond drilling (23,000 feet within the license area) has indicated the following grade and tonnage data for the pyrochlore-bearing carbonatite as reported in the October 6, 1966 issue of the Northern Miner:

> "Intersections cut in a series of holes drilled at 400-foot intervals along the apparent strike of the deposit, indicate a tonnage potential of 40,000 tons per vertical foot averaging 0.52 percent columbium pentoxide (Cb_2O_5). --- significant tonnages of material grading 0.65 to 0.80 percent Cb_2O_5 are indicated ---. Drilling indicates that the structure continues to depth and thus over 40 million tons are indicated to a depth of 1,000 feet."

A revised estimate in the April 13th, 1967 issue of the Northern Miner presented the following data:

> "Drilling has defined a deposit containing a minimum of 80,000 tons per vertical foot which grades in excess of 0.52% columbium pentoxide (Cb_2O_5)."

The known strike length of the body is 2,200 feet with widths up to 200 feet reported.

From the available data on carbonatite occurrences in the Operation Kapuskasing area, the following suggestions may be made:

(a) The carbonatite bodies occur mainly as tabular bodies rather than as circular pipes.

(b) There is a definite spatial association between carbonatite occurrences and zones of northeast-striking faults.

The following geochemical data may be of use in deciding whether or not a carbonate occurrence is of carbonatite origin. Laakso (1961) has shown that the barium-strontium content can be used to differentiate carbonate rocks of different origin. In carbonate rocks of carbonatite origin, the product "barium content X strontium content" (in parts per million) is greater than one million, and the Sr/Ba ratio is generally greater than one (ranging from 0.2 to 100).

DIAMONDS

No diamonds have been reported from within the map-area; however, the discovery of kimberlite in the area and the occurrence of heavy minerals of kimberlitic origin in stream sediments in the region would indicate that diamond pipes could be present (Brown et al, 1967).

CONCLUSIONS

The economic potential of the area covered during Operation Kapuskasing is still very uncertain. There is no reason to doubt that significant mineral occurrences are present in the area but the problems involved in locating them will be considerable. The thick overburden cover and poor rock exposure will necessitate the use of geophysical and geochemical exploration techniques. As suggested in the "Pleistocene" section of this report the use of geochemical methods will be made difficult by the complex Pleistocene history of the area.

Recommendations regarding the occurrence of various features of economic interest have been given in the "Economic Geology" section of this report.

INDUSTRIAL MINERALS

By

G. R. Guillet[1]

Industrial minerals are potentially important in the area, particularly in the Mesozoic and Paleozoic formations of the Moose River basin. Large reserves of kaolin (china clay), fireclay, silica sand, lignite, gypsum, limestone, common clay, peat moss, and sand and gravel are present. The high quality of many of these commodities has been established. Only remoteness, and in some cases depth of overburden, has prevented their commercial development.

Reports by W.S. Dyer, A.R. Crozier, R.J. Montgomery, and R.J. Watson (see references) are the most complete studies on the industrial mineral resources of the area. Recent activities are recorded in unpublished reports on open file at offices of the Ontario Department of Mines in Timmins and Toronto.

Company	Date of Exploration	Ontario Dept. Mines File No.
American Nepheline Ltd.	1959-60	83.1-18
Franc R. Joubin and Associates Ltd.	1962-63	83.1-35
Chesterfield Mining and Exploration Co. Ltd.	1962-63	83.1-37
W.G. Wahl Limited	1962-63	83.1-30
Moosonee Gypsum and Exploration Co.	1963	83.1-20
Algoma Central and Hudson Bay Railway	1965-66	83.1-44

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[1] Geologist, Industrial Minerals Section, Ontario Department of Mines, Toronto.

KAOLIN - FIRECLAY - QUARTZ SAND

The occurrence of Mesozoic sedimentary rocks in the Moose River basin is unique in Ontario. These rocks are of two types: 1) Unconsolidated quartz sand with a kaolin matrix, containing lenticular beds of variously-coloured fireclays, and 2) dark grey fireclay and interbedded lignite. Occurrences of the first type are restricted to an area marginal to the Precambrian escarpment, outcroppings being few and widely scattered in the deeply-cut banks of the Mattagami and Missinaibi Rivers. Occurrences of the second type are found over a smaller area, and are best developed in the vicinity of Onakawana on the Abitibi River. The two areas appear to be separated by the Grand Rapids arch, a barrier which may have restricted the movement of quartz sand further north.

Dyer (1929, p.59) suggests the source of the kaolin and quartz sand was a residual kaolin deposit on the granite escarpment to the south. Kaolinized feldspars have been reported in the source area to support this view. The white and brightly-coloured fire-clays near the foot of the escarpment suggest deposition in a fresh-water lake under oxidizing conditions. The dark-coloured fireclays north of the Grand Rapids arch are indicative of a reducing environment, a condition necessary for the preservation of the associated lignite beds. The two lake basins were undoubtedly connected by streams, or by overflow in times of flood, which permitted the transport of suspended clay particles into the lignite area.

The quartz sands of the upper basin are composed of clear, colourless, rather angular quartz grains, ranging in size largely between ¼-inch and 100 mesh. Generally less than 5 percent of the quartz sand is finer than 100 mesh. The washed sand, with the minus 100 mesh material removed, typically contains 0.01 - 0.05 percent Fe_2O_3, a glass-grade silica sand.

Kaolin, that commonly is present in the matrix of the sand in amounts up to 15 percent, is white or near-white in colour. Brightness of the raw clay is 70-80 relative to a magnesium carbonate standard. Kaolin separated from the sand burns to a white or cream colour at cone 10 and fuses at cone 34. Some quartz is present in the very fine sizes, making complete separation of quartz and kaolin difficult. But for this residual quartz grit, the clay appears suitable for paper coating or filler. The degree of contamination is indicated by the chemical analyses in Table 5. The first analysis is of the minus 325 mesh (44 micron) portion of a sample of kaolinitic quartz sand taken from a surface exposure on the east bank of the Mattagami River in Kipling township; the analysed portion represents 12.4 percent of the total sand sample. The second analysis is of a water-washed sample of minus 5 micron material from a drillhole west of the Mattagami River in Kipling township; the analysed portion represents 7.1 percent of the total sample. Both analyses are from Ventures Limited (1960, unpublished report).

Table 5 | Chemical analyses of kaolin

	1 Surface Sample (minus 325 mesh) percent	2 Drillhole sample (minus 5 micron) percent
SiO_2	51.80	
Al_2O_3	33.05	36.07
Fe_2O_3	0.84	1.64
TiO_2	0.70	
CaO	0.03	0.36
MgO	0.09	
Loss on ignition	11.72	13.68

The Al_2O_3 analyses indicate the proportion of kaolinite in the sample; its increase in the finer sizes is apparent. Theoretically pure kaolinite is composed of 39.50 percent Al_2O_3, 46.54 percent SiO_2, and 13.96 percent H_2O.

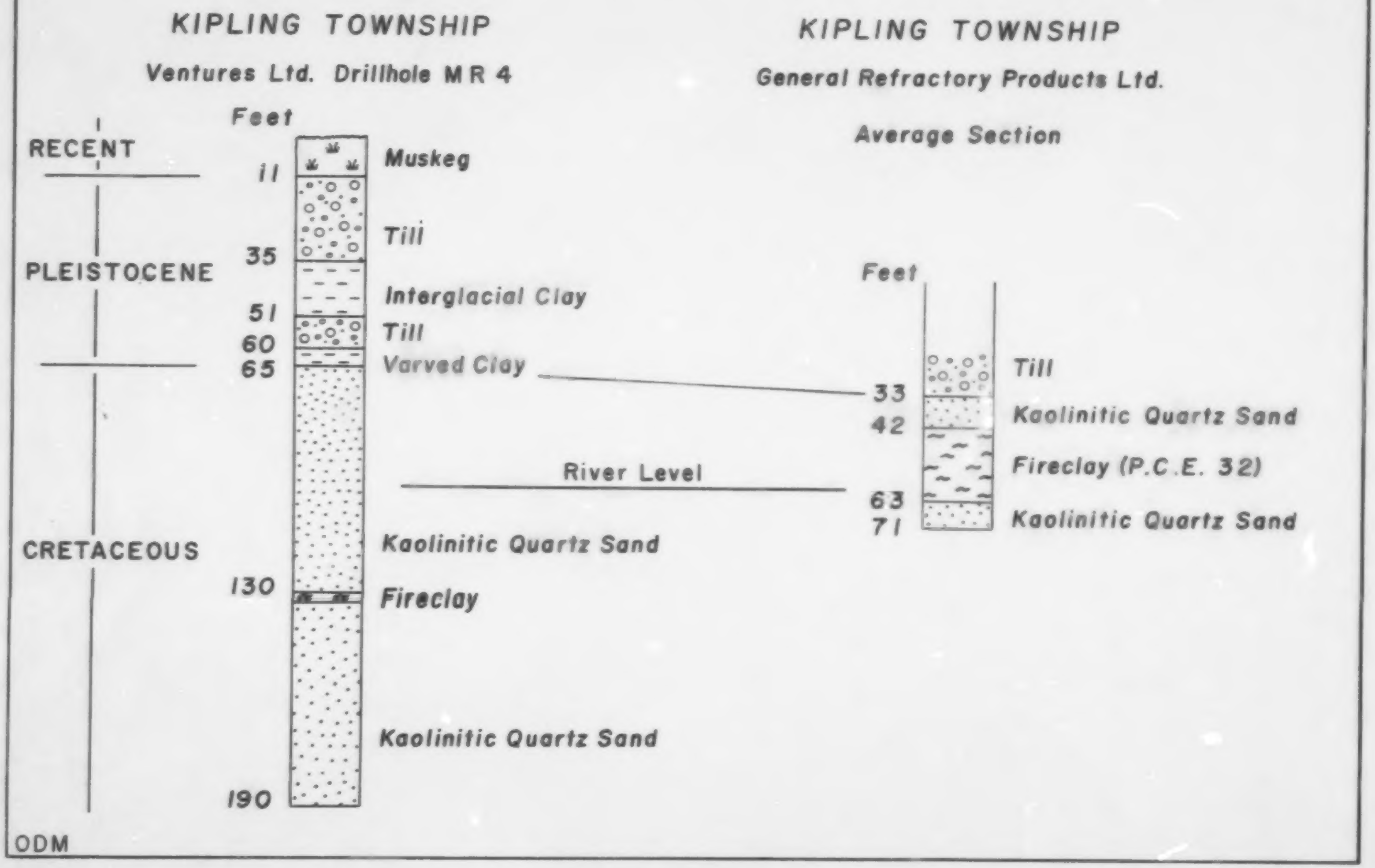
Lenticular beds of smooth, highly-plastic, white or brightly coloured clays are irregularly distributed throughout the kaolinitic sand. Cream-white, rusty-brown, grey, green, and red varieties occur. The beds are horizontal and vary up to 20 feet in thickness. They may owe their origin to occasional dry periods, when evaporation of the lake waters caused the rapid deposition of suspended clay in shallow disconnected depressions on the lake bottom. These clays consist almost entirely of kaolinite, and many have fusion cones of 26 to 32. They would appear to have value for low and medium-duty firebrick, and with suitable fluxes, sewer pipe and brick.

These Cretaceous sedimentary rocks are nowhere exposed above the muskeg. Outcrops are found only in the banks of the major rivers. The best exposures are on the Mattagami River in Kipling township, Coal Creek and the Missinaibi and Pivabiska Rivers in McBrien township, and at several locations on the Missinaibi River in Habel township. The most serious attempt at commercial production was made in 1942-3 when 898 tons of fireclay and 86 tons of silica sand were shipped from an open pit on the property of General Refractory Products Limited. The pit is located on the west bank of the Mattagami River ¼-mile north of the Kipling generating station in Kipling township. An average geological section based on drilling data in the pit area is shown in Figure 15, along with a drillhole section 2 miles to the northwest. Lateral variability in the Cretaceous section is obvious. Also impressive is the great thickness of kaolinitic quartz sand which to date has not been bottomed. Overburden is thinner than normal at both sites.

LIGNITE - FIRECLAY

Dark grey fireclay, interbedded with thick seams of lignite, characterize the Cretaceous rocks in the lower basin, lying between the Grand Rapids arch and the Moose River arch. Onakawana is located near the centre of this basin, on the Abitibi River some 50 miles northeast of the light-coloured sands and clays of Kipling township, previously described.

Fig. 15 — Geologic Sections KAOLIN - FIRECLAY - QUARTZ SAND AREA.


KIPLING TOWNSHIP
Ventures Ltd. Drillhole M R 4
Feet
RECENT
PLEISTOCENE
CRETACEOUS
11
35
51
60
65
130
190
Muskeg
Till
Interglacial Clay
Till
Varved Clay
River Level
Kaolinitic Quartz Sand
Fireclay
Kaolinitic Quartz Sand
KIPLING TOWNSHIP
General Refractory Products Ltd.
Average Section
Feet
33
42
63
71
Till
Kaolinitic Quartz Sand
Fireclay (P.C.E. 32)
Kaolinitic Quartz Sand
ODM

Lignite occurring near the surface at Onakawana was the object of an extensive drilling program by the Ontario Department of Mines during the years 1927-33 and the T. & N.O. Railway in the period 1939-41. About 300 holes were drilled in Dyer and Morrow townships and several shafts were put down. In 1945-6 a pilot plant was operated at Onakawana to produce a beneficiated lignite fuel, using raw lignite obtained from an open pit on the west bank of the Abitibi River.

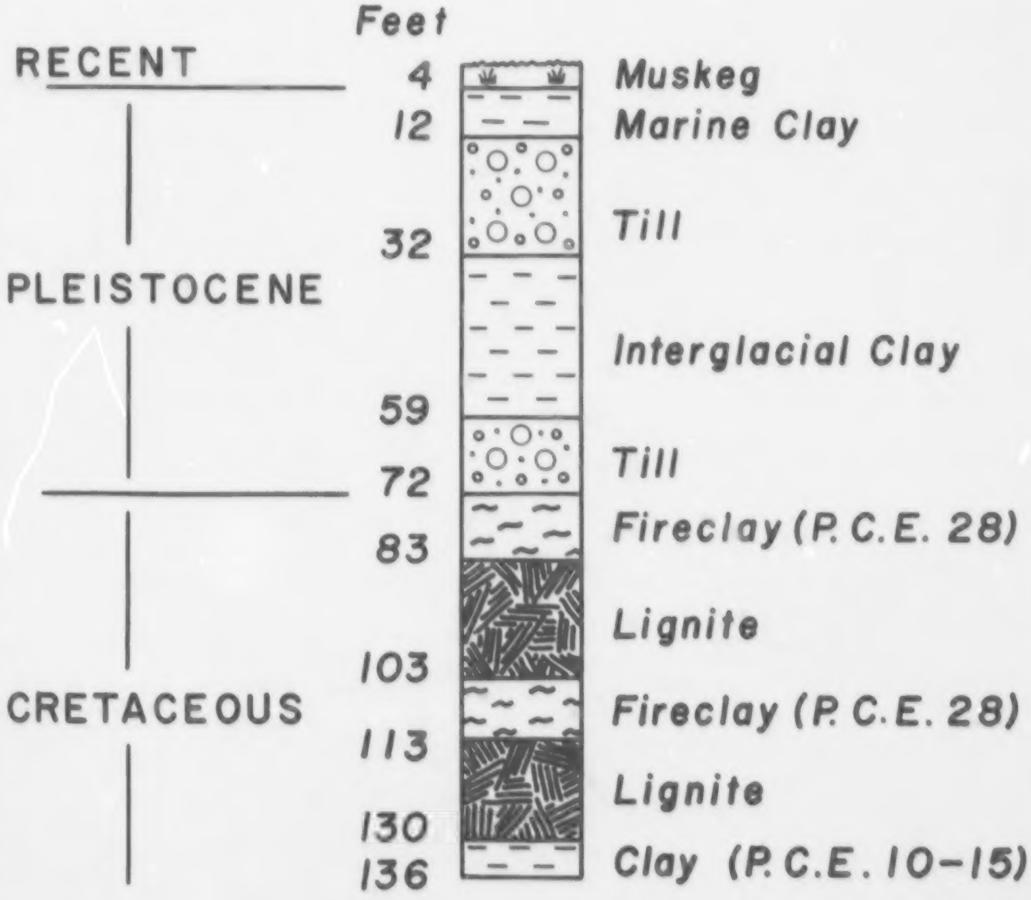
Drilling indicated two lignite seams separated and overlain by fireclay; a typical section is shown in Figure 16. Thicknesses of the lignite and fireclay beds vary rapidly over short distances, due principally to glacial gouging and crumpling. A total of 10 million tons of raw lignite were proven by extensive drilling in two areas: Area A, comprising 100 acres, extends between the Abitibi River and the railway track; area B lies between the railway track and the Onakawana River, and comprises 143 acres. Overburden averages 54 and 58 feet in the two areas respectively, and totals 21 million cubic yards. Scattered drilling beyond these areas indicates the ultimate lignite reserves are much greater, but this at the expense of somewhat increased overburden.

The raw lignite consists of a mixture of woody, peaty, and earthy varieties, the whole averaging 50 percent moisture and 5 percent ash, with a heat value of 5,000 B.T.U. per pound. Beneficiation by the Fleissner process, using steam autoclaves for drying, resulted in the production of 1 ton of

Fig. 16 — GEOLOGIC SECTION — LIGNITE — FIRECLAY AREA

DYER TOWNSHIP

Onakawana Shaft W.


Feet
RECENT
4
Muskeg
12
Marine Clay
32
Till
PLEISTOCENE
Interglacial Clay
59
Till
72
Fireclay (P.C.E. 28)
83
Lignite
103
CRETACEOUS
Fireclay (P.C.E. 28)
113
Lignite
130
136
Clay (P.C.E. 10-15)

ODM

processed lignite from 3 tons of raw feed. Lignite so produced contained 25 percent moisture, 7.4 percent ash, and had a heat value of 8,100 B.T.U. per pound. With a general easing of the fuel shortage which had developed during the war years, and when the anticipated market as fuel for railway locomotives and stationary heating plants did not materialize, the project was abandoned.

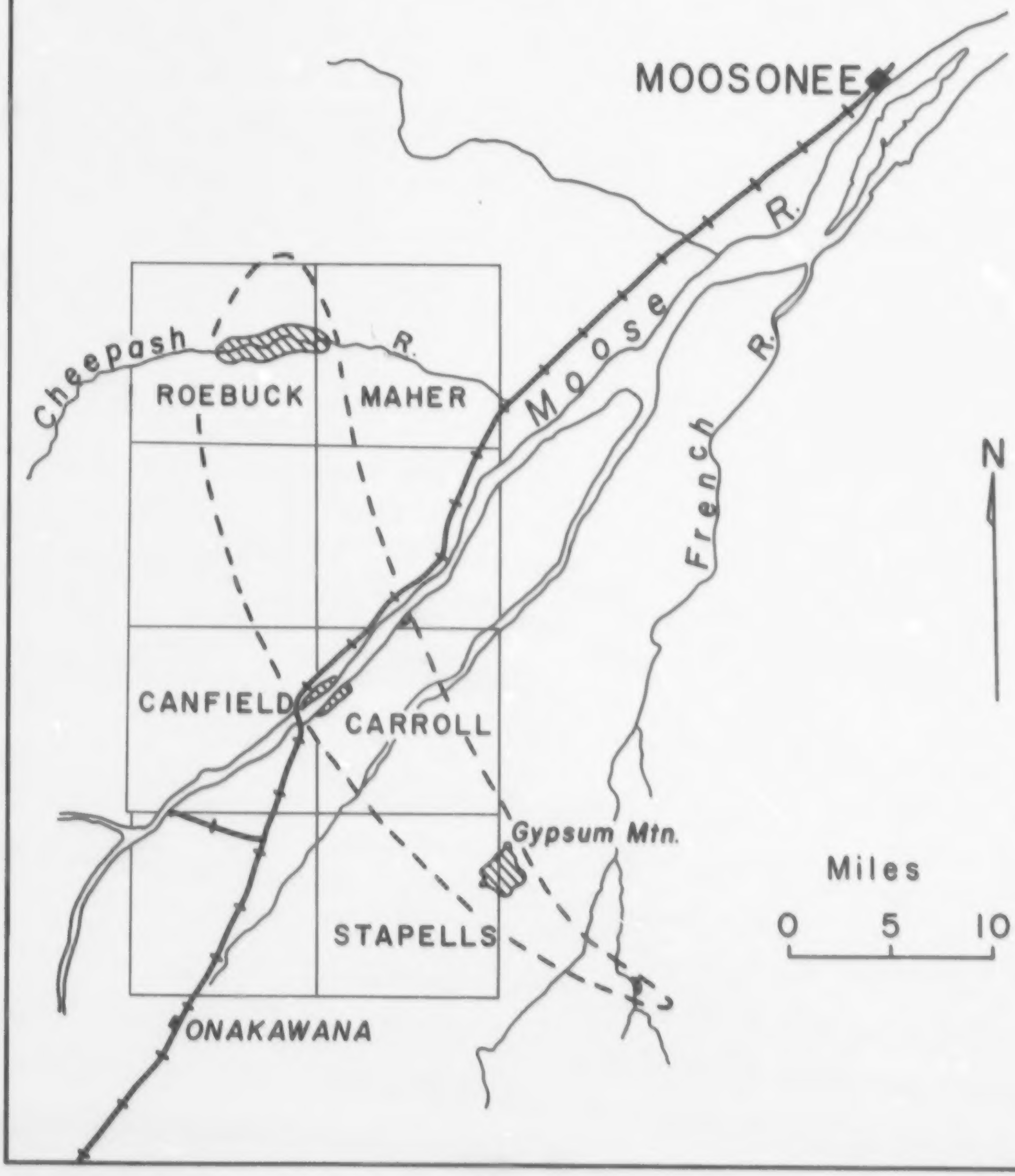
The lignite basin apparently was a shallow one. The two main beds of lignite are thought to have formed in situ under swamp conditions. The two fireclay beds apparently represent lake conditions, probably fed by flood-overflow from the upper basin. The dark-coloured, highly-plastic, clays burn to light colours and have fusion temperatures (P.C.E.) of about cone 28.

GYPSUM

Massive, white, gypsum of Middle Devonian age, outcrops at intervals over a distance of 40 miles along the northwesterly-trending Moose River arch. There are four main outcrop areas (see Figure 17), designated from northwest to southeast as the Cheepash River occurrences, the Moose River Crossing area, Gypsum Mountain, and the French River occurrence. Much of the intervening muskeg is modified by a karst topography suggesting the near-surface occurrence of gypsum.

Gypsum, limestone, and shale, and mixed breccias of these rocks, make up most of the Middle Abitibi River Formation, formerly known as the Moose River Formation. In most places

Fig. 17 - GYPSUM IN THE MOOSE RIVER BASIN


MOOSONEE
Moose R.
French R.
Cheepash R.
ROEBUCK
MAHER
CANFIELD
CARROLL
STAPELLS
Gypsum Mtn.
ONAKAWANA
N
Miles
0
5
10

the gypsum is white, massive, fine- to medium-grained, and of high purity. Samples consistently average more than 90 percent gypsum. Thin crenulated laminae of limestone or shale delineate the colloform structures of the gypsum. Detailed studies of the gypsum outcrops are given in a separate report (Guillet, 1964 , p. 35-70).

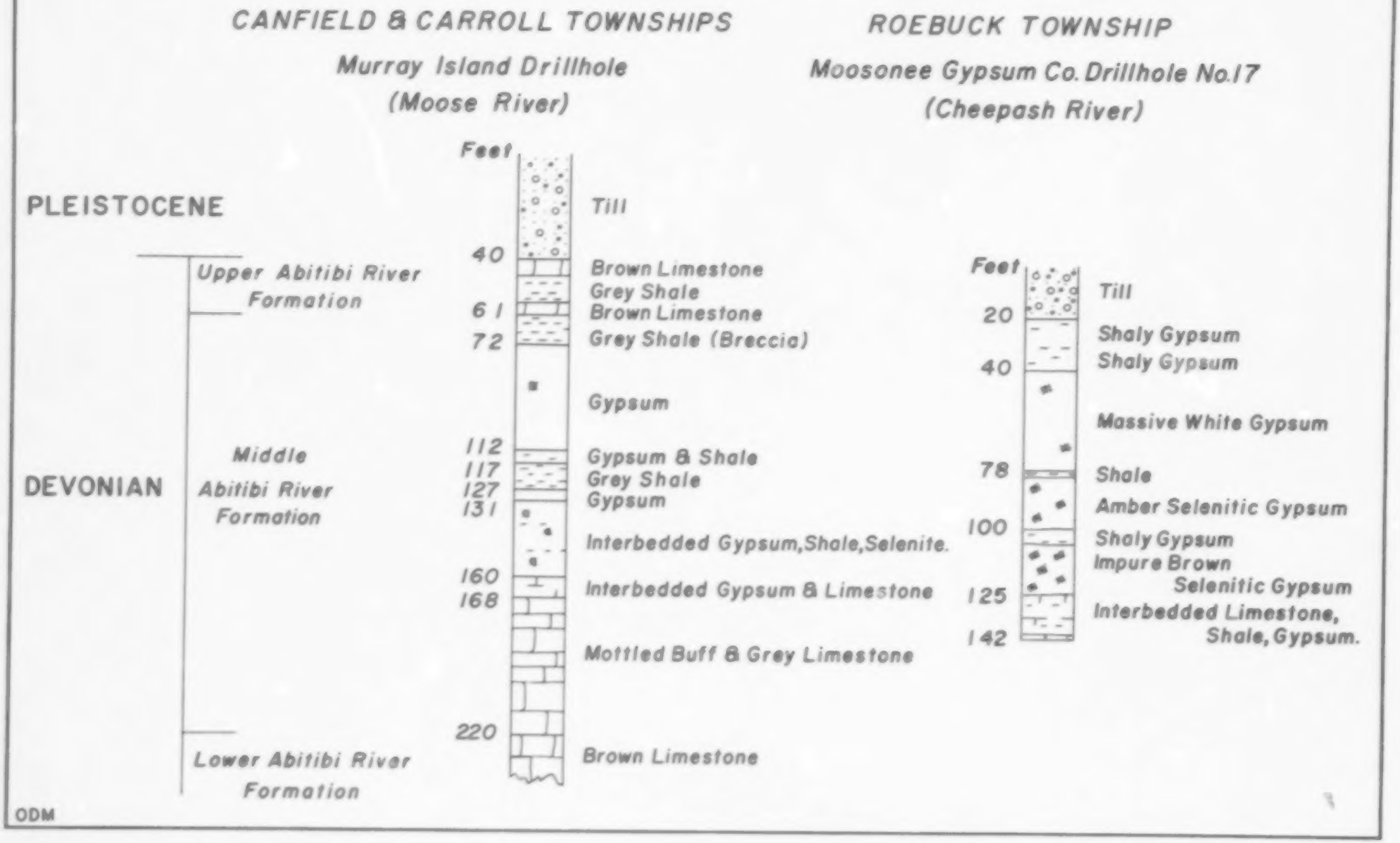
Cheepash River Occurrences

In Roebuck township gypsum is almost continuously exposed for 5½ miles along the Cheepash River. The river banks expose up to 25 feet of white, medium-grained, massive, colloform gypsum with very minor amounts of brown limestone laminae. During the fall of 1963 Moosonee Gypsum Company carried out a drilling program that proved the continuation of the gypsum to a depth of 125 feet (see Figure 18). Their drilling also confirmed an extremely scalloped gypsum surface caused by deep glacial gouging and solution.

Moose River Crossing

Gypsum, gypsum breccia, and limestone are continuously exposed in both river banks over a distance of 2½ miles on the downstream side of the Moose River railway crossing. Gypsum is also exposed for ½-mile on the southeast shore, 7 miles downstream from the railway bridge. The outcrops consist typically of 10-15 feet of gypsum-limestone breccia overlying,

Figure 18 — Geologic Sections — GYPSUM AREA


CANFIELD & CARROLL TOWNSHIPS
Murray Island Drillhole
(Moose River)
ROEBUCK TOWNSHIP
Moosonee Gypsum Co. Drillhole No.17
(Cheepash River)
PLEISTOCENE
DEVONIAN
Upper Abitibi River Formation
Middle Abitibi River Formation
Lower Abitibi River Formation
Feet
40
61
72
112
117
127
131
160
168
220
Till
Brown Limestone
Grey Shale
Brown Limestone
Grey Shale (Breccia)
Gypsum
Gypsum & Shale
Grey Shale
Gypsum
Interbedded Gypsum, Shale, Selenite.
Interbedded Gypsum & Limestone
Mottled Buff & Grey Limestone
Brown Limestone
Feet
20
40
78
100
125
142
Till
Shaly Gypsum
Shaly Gypsum
Massive White Gypsum
Shale
Amber Selenitic Gypsum
Shaly Gypsum
Impure Brown Selenitic Gypsum
Interbedded Limestone, Shale, Gypsum.
ODM

and in sharp contact with, 4 feet of wavy-bedded, resinous-brown and white, coarsely recrystallized selenitic gypsum. Massive, medium-grained, white gypsum, containing numerous "eyes" and healed fractures of recrystallized brown selenite, and minor thin limy laminae, underlie the brown and white gypsum zone. Thin-bedded, fine-grained brown limestone overlies the gypsum sequence near the extremities of the gypsum outcrop areas. On the northwest shore the terraced river bank is 25 feet high, the upper 10 feet (above the gypsum sequence) consisting of till and river sands. On the southeast shore the bank is 45 feet high, of which 20-25 feet is overburden.

In 1929 the James Bay Basin Oil Company Limited drilled three holes on the islands upstream from the Moose River bridge. One at the head of Mike Island, 2 miles upstream from the last gypsum outcrop, encountered gypsum interbedded with shale and limestone through a vertical range of 200 feet. Another, drilled at the head of Murray Island, almost opposite the last gypsum outcrop, intersected 96 feet of gypsum. The section indicated by the latter hole is illustrated in Figure 18.

Gypsum Mountain

White, massive, sugary gypsum, in banks 15-20 feet high, outcrops above the muskeg near the east boundary of Stapells township. The occurrence, known as "Gypsum Mountain", covers an area of 3-4 square miles. An interesting weathering feature is the occurrence of a series of natural arches, 60 feet or more across, that have formed by solutioning along two watercourses that transect the area in north-south and east-west directions. Gypsum Mountain represents the peak elevation of the gypsum sequence above sea level.

French River

Several small outcrops of gypsum occur over a distance of ½-mile on the east bank of the central branch of the French River. (The central branch of the French River is called the Wakwayowkastic River). The outcroppings expose a 6-8 foot section of good quality white, finely granular, massive gypsum with traces of grey-black, crenulated, limestone laminae.

LIMESTONE

Much of the limestone of the Upper Abitibi River Formation is of the high-calcium variety. In southwestern Ontario its equivalent is the Detroit River Formation, the source of most of the chemical lime produced in the province. Exposures of Upper Abitibi River Limestone are widespread in the Moose River basin. In the north, outcrops are common on the Kwataboahegan and French rivers. At Grand Rapids on the Mattagami River 50-foot limestone cliffs extend for 2 miles on both sides of the river. At Coral Rapids on the Abitibi

River 40-foot limestone banks extend for 1,000 feet, within sight of the O.N.R. Dyer (1929, p.68) gives the following analysis for the Coral Rapids section:-

Table 6 | Chemical analysis of limestone, Coral Rapids

	Percent
$CaCO_3$	95.46
$MgCO_3$	1.09
Al_2O_3 & Fe_2O_3	1.85
Acid insoluble	2.42
	100.82

PETROLEUM

Although there are suitable structures and favourable reservoir rocks in the James Bay Lowland, Martison (1952, p.57) states that there is no evidence of gas, petroleum, or its residues in any of the sedimentary rocks. Silurian and Devonian rocks, some of which are equivalent to producing horizons in southwestern Ontario, are known to occur in thicknesses greater than 1,400 and 800 feet respectively.

COMMON CLAY

The area is almost everywhere mantled by unconsolidated Pleistocene deposits, in most cases topped by muskeg. The Pleistocene materials include sand and gravel, till, and various stoneless clays: Marine clay, flood plain clay, stratified lake clay, varved clay, and stoneless till.

Distribution of the Pleistocene materials throughout much of the area is discussed by Keele (1920).

The clays are all highly calcareous, owing to their glacial derivation from the limestones of the Paleozoic plain. They are poorly suited for the manufacture of clay products. Drain tile are made from similar clays in southern Ontario, and brick were formerly made, but modern standards require brick of much lower absorption than can be produced from the soft, porous-firing, calcareous clays.

Test results on several samples taken in 1962 are given in the following notes. Descriptions of other clay testing along the line between Cochrane and Hearst are given by Keele (1924, p.118-120).

Hearst

A 3-foot section of laminated brown clay is exposed in a roadcut on highway No. 583 $\frac{1}{4}$-mile south of the Mattawishkwia River bridge near the southern limits of Hearst. The clay appears to continue to a greater depth. Stones are rare.

A partial analysis shows the composition to be 14.3 percent CaO and 4.79 percent Fe_2O_3. A mineral analysis shows illite and chlorite to be present in abundant and moderate amounts respectively. Principal non-clay minerals include quartz (17 percent), calcite (17 percent), and dolomite (11 percent).

Ceramic tests indicate the clay is quite plastic and inclined to crack on drying. Lineal drying shrinkage is 5 percent. The clay burns to a buff-coloured, porous, moderately hard body at cone 06 (1840°F). Absorption by immersion for 24 hours in cold water is 24 percent; after 5-hour boiling is 27 percent.

Kapuskasing

A 7-foot section of coarsely stratified brown clay and silt was sampled in a 13-foot bank of the Kapuskasing River about 2 miles southwest of the town of Kapuskasing. The section consists of buff-coloured silt layers 3-6 inches thick, alternating with brown plastic clay layers 1-3 inches thick.

A partial chemical analysis shows a CaO content of 17.3 percent, Fe_2O_3 3.67 percent. A mineral analysis indicates both illite and chlorite are abundant. Principal non-clay minerals are quartz (16 percent), calcite (18 percent), and dolomite (13 percent).

As with the Hearst sample, this clay is quite plastic and requires careful drying to avoid cracking. Lineal drying shrinkage is 5 percent. It burns to a cream-coloured body of moderate hardness at cone 06 (1840°F). Absorption by immersion for 24 hours in cold water is 23 percent; after 5-hour boiling is 25 percent.

Cochrane

A 30-foot bank of clay till is exposed at the bridge over the Buskegau River on highway No. 11 eleven miles west of

Cochrane. The top half of the section is almost stonefree. Stones that are present are largely Precambrian pebbles, commonly less than 1 inch in diameter but occasionally of boulder size. The lower part of the bank consists of medium grey till, dense, massive, smooth, and plastic. The top 5 feet is oxidized to a buff-drying, medium brown colour, and is loamy-textured beneath the topsoil.

A 7-foot vertical channel sample of the grey till, and a 5-foot sample of the brown oxidized till, proved to be practically identical on analysis. Partial chemical analyses gave 13.0 percent CaO, 3.74 percent Fe_2O_3. Mineral analyses showed illite and chlorite both present in moderate amounts. The principal non-clay minerals are quartz (22 percent), calcite (15 percent), and dolomite (16 percent).

Ceramic tests indicate the clay has moderate plasticity but high lineal drying shrinkage ($5\frac{1}{2}$ percent). It burns to a hard cream-coloured body at cone 06 (1840°F). Absorption by immersion in cold water for 24 hours is 17 percent; after 5-hour boiling is 19 percent. Fusion points of these clays, and those from Hearst and Kapuskasing, are cones 4-5.

Clay Till

The most common deposit of the last glaciation is dense grey till. While till sheets may be irregularly broken by silty sections and lenses of sand, gravel, and stoneless clay, the typical clay till is a dense, massive, impervious clay containing a moderate number of rounded pebbles in completely random distribution. Such material is practically worthless. However, the Ontario Hydro made extensive use of this material for dikes and the cores of power-dams in the construction of the Mattagami River generating stations.

SAND AND GRAVEL

Reserves of sand and gravel are ample throughout the area. While no particular examinations were made of sand and gravel deposits for the present study, a number of large eskers that cross highway No. 11 between Kapuskasing and Cochrane are known. Eskers consist of stratified sand and gravel deposited by streams running in channels carved into the base of the glacial ice. They form sinuous ridges typically persisting for some miles in north-south directions. Raised beaches, composed of stratified sand and gravel, mark stages in the recession of the sea northward across the James Bay Lowland. They, with occasional spillway deposits exposed in terraces along the major rivers, are resources for northern construction.

PEAT MOSS

Peat moss is plentiful throughout the area. While no study was made for the present report it is known that peat moss should be relatively fresh for horticultural uses where cellular structure is important for moisture retention.

Humified, or decomposed, peat is common in the lower levels of peat bogs, so that a factor of first importance in the evaluation of a bog is the thickness of the fibrous layer at the top.

SELECTED REFERENCES

Books

Baker, M.B.

1911: Iron and lignite in the Mattagami basin; Ontario Bur. Mines, Vol. XX, pt. 1, p. 214-246.

Bell, J.M.

1904: Economic resources of Moose River basin; Ontario Bur. Mines, Vol. XIII, pt. 1, p. 135-179.

Bell, Robert

1875: Exploration in 1875 between James Bay and Lakes Superior and Huron; Geol. Surv. Canada, Rept. of Progress, 1875-76, p. 294-392.

Boissonneau, A.N.

1966: Glacial history of northwestern Ontario; Canadian Jour. Earth Sci., Vol. 3, No. 5, p. 559-578.

Borron, E.B.

1891: Report on the basin of Moose River; Ontario Sessional Papers No. 87.

Brown, D.D., Bennett, G., and George, P.T.

1967: The source of alluvial kimberlite indicator minerals in the James Bay Lowland; Ontario Dept. Mines, Misc. Paper, MP. 7.

Cross, J.G.

1920: The Abitibi and Mattagami rivers, north of the National Transcontinental Railway, I. Pre-Cambrian rocks and iron ore deposits; Ontario Dept. Mines, Vol. XXIX, pt. 2, p. 1-18.

Crozier, A.R.

1933: Refractory clay deposits on the Missinaibi River; Ontario Dept. Mines, Vol. XLII, pt. 3, p. 88-101.

Dyck, W., Lowden, J.A, Fyles, J.G., and Blake, W. Jr.

1966: Geological Survey of Canada radiocarbon dates V; Geol. Surv. Canada, Paper 66-48, p. 10-11.

Dyer, W.S.

1928: Geology and economic deposits of the Moose River basin; Ontario Dept. Mines, Vol.XXXVII, pt. 6, p. 1-69.

1929: Limestones of the Moose River and Albany River basin; Ontario Dept. Mines, Vol. XXXVIII, pt. 4, p. 31-33.

1930: The Onakawana lignite deposit, Moose River basin (Progress Report to May 31, 1930), in Investigations of non-metallic mineral resources of Ontario, 1929; Ontario Dept. Mines, Vol. XXXIX, pt. 6, p. 1-14.

1932: Stratigraphy and oil and gas possibilities of Moose River basin; Geol. Surv. Canada, Econ. Geol. Ser. No. 9, p. 89-103.

Dyer, W.S., and Crozier, A.R.

1933: Lignite and refractory clay deposits of the Onakawana lignite field; Ontario Dept. Mines, Vol. XLII, pt. 3, p. 46-78.

Fahrig, W.F., Gaucher, E.H., and Larochelle, A.

1965: Paleomagnetism of diabase dikes of the Canadian Shield; Canadian Jour. Earth Sci., Vol. 2, No. 2, p. 278-298.

Ferguson, S.A.

1955: Alfred Trousse claims, Lowther township; Ontario Dept. Mines, Assessment Files, Timmins, Ontario.

Gaucher, E.H.

1966: Elsas-Kapuskasing-Moosonee magnetic and gravity highs; in Report of Activities, Geol. Surv. Canada, Paper 66-1, p. 189-191.

Gittens, J., MacIntyre, R.M., and York, D.

1967: The ages of carbonatite complexes in eastern Canada; Canadian Jour. Earth Sci. (in press).

Guillet, G.R.

1964: Gypsum in Ontario; Ontario Dept. Mines, Industrial Mineral Rept. No. 18.

Hogg, Nelson

1947: Report on Mosher discovery of radioactive mineral, Pitt township, District of Cochrane; Ontario Dept. Mines, Preliminary Rept. P.R. 1948-7.

Hughes, O.L.

1956: Surficial geology of Smooth Rock, Cochrane District, Ontario; Geol. Surv. Canada, Paper 55-41.

1961: Preliminary report on borings through Pleistocene deposits, Cochrane District, Ontario; Geol Surv. Canada, Paper 61-16.

Innes, M.J.S.

1960: Gravity and isostasy in northern Ontario and Manitoba; Dominion Observatory, Ottawa, Vol. XXI, pt. 6.

Keele, Joseph

1920: The Abitibi and Mattagami rivers north of the National Transcontinental Railway, III. Clay and shale deposits; Ontario Bur. Mines, Vol. XXIX, pt. 2, p. 31-55.

1924: Preliminary report on the clay and shale deposits of Ontario; Geol. Surv. Canada, Mem. 142.

Laakso, R.K.

1961: The geochemistry of certain Precambrian carbonate rocks; unpublished M.Sc. thesis, Queen's University, Kingston, Ontario.

LeRoy, O.E.

1902: Quoted by Wilson, W.J., Reconnaissance surveys of four rivers, southwest of James Bay; Geol. Surv. Canada, Summ. Rept. 1902 (Annual Rept. 1902-03), p. 237A.

Lumbers, S.B.

1962: Steele, Bonis, and Scapa townships; Ontario Dept. Mines, Geol. Rept. No. 8.

Martison, N.W. et al

1952: Petroleum possibilities of the James Bay Lowland area; Ontario Dept. Mines, Vol. LXI, pt. 6, p. 1-157.

McLearn, F.H.

1926: The Mesozoic and Pleistocene deposits of the Lower Missinaibi, Opazatika, and Mattagami rivers, Ontario; Geol. Surv. Canada, Summ. Rept., pt. C, p. 16-47.

Montgomery, R.J.

1930: Testing of fire brick made from Mattagami River fire clay, in Investigations of non-metallic mineral resources of Ontario, 1929; Ontario Dept. Mines, Vol. XXXIX, pt. 6, p. 15-21.

Montgomery, R.J., and Watson, R.J.

1928: Fire clay, kaolin, and silica sand deposits of the Mattagami and Missinaibi rivers; Ontario Dept. Mines, Vol. XXXVII, pt. 6, p. 80-120.

Nelson, S.J., and Johnson, R.D.

1966: Geology of Hudson Bay basin; Bull. Canadian Petroleum Geol., Vol. 14, No. 4 (Dec. 1966), p. 520-578.

Prest, V.K.

1957: Pleistocene geology and surficial deposits; in Geology and Economic Minerals of Canada; Geol. Surv. Canada, Econ. Geol. Series No. 1, p. 443-495.

Remick, J.A.

1966: Geologist, Quebec Dept. Natural Resources, personal communication.

Terasmae, J., and Hughes, O.L.

1960: A palynological and geological study of Pleistocene deposits in the James Bay Lowlands, Ontario; Geol. Surv. Canada, Bull. 62.

Walker, T.L.

1932: Thomsonite from Sextant Rapids, Temiskaming District, Ontario; Univ. Toronto Studies, Geol. Series, No. 32, p. 5.

Wilson, H.D.B., and Brisbin, W.C.

1965: The Mid-North American ridge structure; in Geol. Soc. America, Abstracts for 1965, Special Paper No. 87, p. 186-187.

Maps

Ontario Department of Lands and Forests
Map S. 365 Algoma-Cochrane, Surficial Geology. Scale 1 inch to 8 miles. Geology by A.N. Boissoneau, 1962 to 1963. Published 1965.

Ontario Department of Mines
Maps P. 370 Otter Rapids Sheet
371 Kesagami Lake Sheet
372 Cochrane Sheet
373 Burntbush River Sheet
375 Onakawana Sheet
376 Partridge River Sheet
395 Pivabiska River Sheet
396 Little Long Rapids Sheet
397 Hearst Sheet
398 Kapuskasing Sheet

Scale 1 inch to 2 miles. Geology by G. Bennett, D.D. Brown, P.T. George, and E.J. Leahy, 1966.